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and to Methods and Costs of Construction

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Roads and Streets—1st Wednesday
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(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
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Railways and Excavation—3rd Wednesday
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Buildings and Structures—4th Wednesday
(a) Buildings
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(d) Miscellaneous Structures
(e) Properties of Materials

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Forty-eight Laboratories of Social Science

The 48 states of the Union, are 48 experimental laboratories of social science. No other nation has ever had more than a few such laboratories. Certainly no other nation has made as many experiments in government as have been made in the United States during the past century.

It is not easy to estimate the economic advantage of experimenting on a small scale, for making sweeping changes on a large scale, whether in political or in industrial affairs. But anyone familiar with the history of even a fraction of the experiments made by our states knows that for every successful experiment there have been fully a score of failures. Had these experiments been conducted by the entire nation, we might long ago have sickened of experimenting, because of the excessive cost of trying out new schemes on so large a scale.

Prohibition was first tried in Maine, if we remember rightly, and then in other states. The growing number of seemingly successful experiments in state prohibition has finally led to national prohibition. Protest as some of us may against this restriction of liberty, at least we can not protest that it lacks evidence in its favor. Few states have ever gone "wet" after once going "dry."

Similarly state experiments in "suffrage" have served as object lessons which will soon result in national suffrage for women.

28 Pages = 40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

Every state in the Union, except Delaware, now has a public service commission that regulates the rates of railways, and in most cases the rates of public utilities. Wisconsin was the first to experiment with a public service commission having broad regulatory powers over all public utilities, but Wisconsin simply "went Massachusetts one better." Other states followed these two.

North Dakota is now experimenting in state ownership of grain elevators, and in state marketing of farm products. Six years ago the state constitution was amended to permit state ownership of elevators. Recently an attempt was made to stop these socialistic experiments in North Dakota. A suit was brought to enjoin the public ownership program on the ground of unconstitutionality, but it has been dismissed by Judge Charles F. Amidon of the U. S. District Court, who said:

"The present movement began at least as far back as 1911. In that year an amendment to the state constitution was initiated authorizing the state to acquire one or more terminal grain elevators and maintain and operate the same in such manner as the legislative assembly should prescribe. That amendment was adopted in 1913.

"From that time forward the discussion of the subject of marketing the products of the state has been the main theme of public thought. The movement has gone straight forward, the constitution has been repeatedly amended, including the amendments here assailed, all having for their object the correction of the existing system of marketing the state's products. Year by year the conviction has deepened, in steadily increasing majorities, that public ownership of terminal elevators, mills and packing houses is the only effective remedy to correct the evils from which they believe themselves to be suffering.

"Their decision is not a popular whim, but a deliberate conviction, arrived at as a result of full discussion and repeated presentations of the subject at the polls. The acts which the court is asked to restrain are not those of public officials who are pursuing enterprises of their own devising. Those acts express not simply the judgment of the state legislature. To authorize their enactment the people of the state have redrawn their constitution. That is the highest and most deliberate act of a free people."

Although we seriously question the economic wisdom of state marketing of farm products, it is certainly desirable to make the experiment on a moderate scale. North Dakota is a farming state. Seventy per cent of its state legislators are farmers. They are determined to try state marketing of farm products. If careful cost and profit records are kept over a term of years they may be able to persuade other states to try the same experiment. In this manner the theory should receive a thorough test on a progressively larger scale, if it shows real merit.

Idealists are generally inexperienced in economics. Having conceived what seem to them to be ideal social states, they wish to bring their ideals into immediate universal existence. They grow impatient when asked to experiment on a small scale first. Practical men who have managed business affairs know that few innovations "pan out" as well as anticipated. Hence their insistence on orderly progress based on small scale experiments. They believe in evolution rather than revolution in economic affairs. Since government is mainly business, they ask that successful business methods be applied in government. Of these methods none has been more successful than experimenting on a moderate scale. Hence the wisdom of the demand that social experiments in America begin with the smaller political units.

Some Common Errors Relative to Public Works' Economics

Most associations of farmers were formerly opposed to bond issues for road improvement, and some of those associations—notably the State Grange of Pennsylvania—still voice an opposition. Perhaps this was to be expected from men whose experiences with "bonded debt" had been only with mortgages on their own land. But whatever the reason for their opposition to bond issues, it is noteworthy that it would have been strong enough a few years ago to have defeated any issue of state road bonds had it not been for the votes of city residents. Now, however, farmers are rapidly becoming convinced that public bonds are good economic instruments.

Much of the opposition to issuing public works bonds is traceable to lack of knowledge of the principles of economics. It is a common mistake, for example, to argue that money paid out by direct taxation for a road is capital upon which no interest charge should be made. If this were so, it would follow that a road built with capital raised by a bond issue is more costly than a road built by direct taxation, for in the former case the interest on the bonds during their life must be added to the first cost of the road, whereas only the first cost exists if the road is built by direct taxation.

The fallacy in this reasoning arises from failure to perceive that the money paid as direct taxes could have been invested by the people from whom it was taken; and that, therefore, the taxpayers are annually losing interest which they otherwise might have received.

Every investment in public works should be charged with annual interest, if it is desired to ascertain the full annual cost of the investment to the taxpayers. The fact that there is no interest to be paid out on a public works investment should not be allowed to obscure the nature of the economic problem; for the investment is not economic unless the profits resulting from it suffice to pay operating and upkeep costs plus interest on the investment throughout the life of the given public works.

Not only many farmers but many business and professional men, including a surprisingly large number of engineers, have erroneous ideas on economic matters of this sort. It should be one of the functions of engineering associations to point out errors such as we have here indicated, for a persisting error may lead the public to foolish opposition to issuing bonds for needed public works, or to an equally foolish belief that a given public plant is profitable although it fails to earn 5 per cent interest, directly or indirectly, on the investment.

Will Nevada Experiment With a State Owned Cement Plant?

About eight years ago the governor of New York recommended that the state manufacture paving brick. Recently a committee of the Illinois Legislature reported in favor of having the state make portland cement. But it has remained for Nevada to be the first actually to make an appropriation for a cement plant.

The Nevada law puts $100,000 at the disposal of a commission, with which to build a cement plant, to supply cement for state roads, if the commission deems it wise. Whether this bill was passed to be used as a club over the cement manufacturers we do not know.

Nevada should buy the idle cement plant that the city of Los Angeles owns and move it to what might prove to be a more healthful economic climate.

If Nevada becomes a pioneer in state manufacturing of cement, it is to be hoped that a detail record of all costs will be kept and published. We predict fully as striking a fiasco as occurred with the cement plant that Los Angeles operated a few years ago and now wishes to unload.

E. & C. Index Furnished Only on Request

Previous to last year it had been our custom to send the index of our articles to all subscribers. In common with many other publishers we now have adopted the practice of sending the index to only such subscribers as request it. Therefore, if you want the index for the 6 months ending June 30 you should notify us at once. Those who requested the index for the previous volume have been listed and need not notify us again.

Light Traffic Roads for Sandy Districts

To the Editor: In an article in your issue of June 4, 1919, entitled "Methods of Constructing Roads Through Sandhill Regions," a statement is made that the material cost of timber track at $5 per 10-ft. section would be about $265 per mile and that a labor and material cost of $8 per 10-ft. section would total about $425 per mile. Evidently, the cost per mile would be about $2,650 and $4,250 instead of the figures given.

Where sagebrush is available a fairly satisfactory road for light travel can be built by spreading a layer of brush over the road and allowing the travel to flatten out the branches. Two years would probably represent the life of such a road. The cost for an 8-ft. strip would be about $400 per mile.

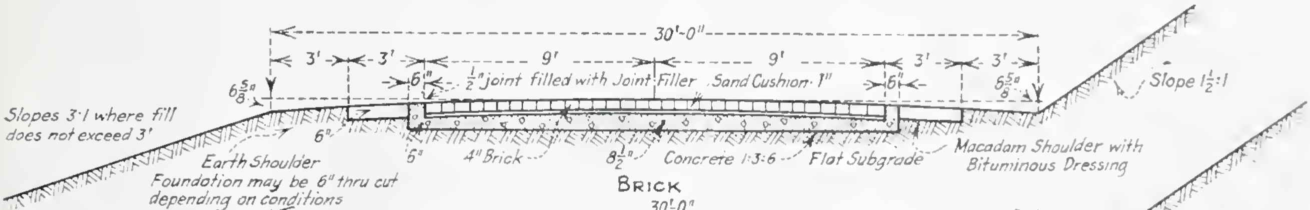
Where gravel is obtainable at a reasonable cost, by laying a foundation of coarse material (between 2 in. and 6 in. in diameter) of about 6 in. and placing top course of finer gravel, a satisfactory road for light traffic is obtained.

Observation of the above roads in this state, in areas of windblown sand, where the annual rainfall averages about 7 in., would indicate that the above types would be useful in many arid, sandy areas.

Ephrata, Wash. NORVAL ENGER.

Southeastern Good Roads Show.—A good roads show and agricultural implement and tractor exposition will be held at Greenville, S. C., July 14-19. F. M. Burnett, Greenville, is general manager of the exposition.

Standard Sections of Highways of New Jersey State Highway Department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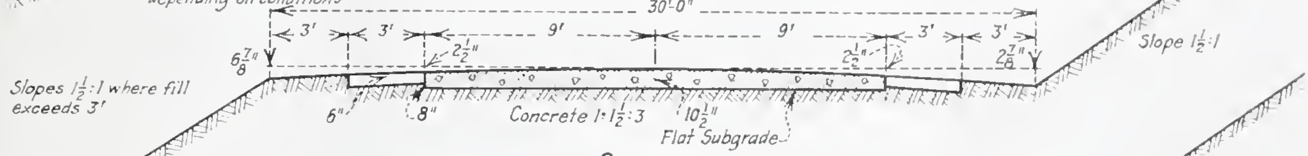
½" joint filled with Joint Filler
Sand Cushion 1"
6"
6⅝"
6⅝"
Slope 1½:1
Slopes 3:1 where fill does not exceed 3'
6"
6"
4" Brick
8½"
Concrete 1:3:6
Flat Subgrade
Macadam Shoulder with Bituminous Dressing
Earth Shoulder
Foundation may be 6" thru cut depending on conditions

BRICK



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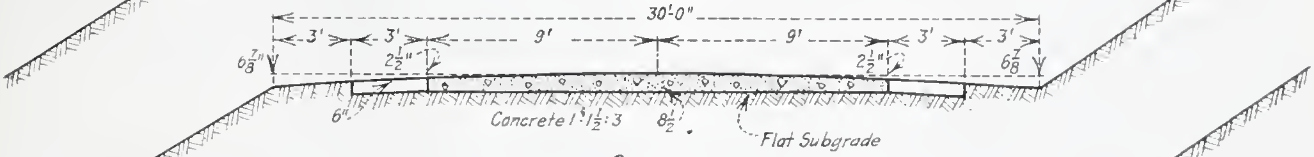

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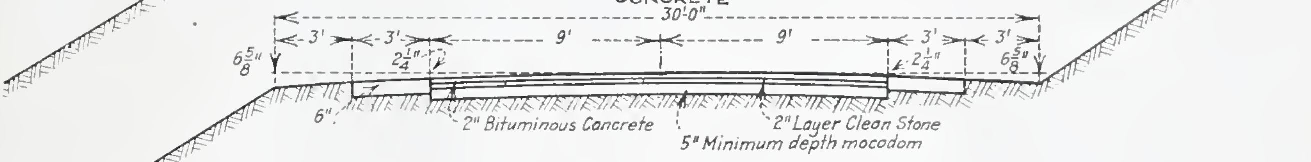

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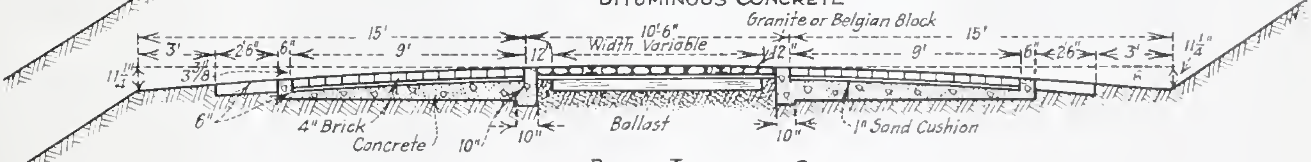

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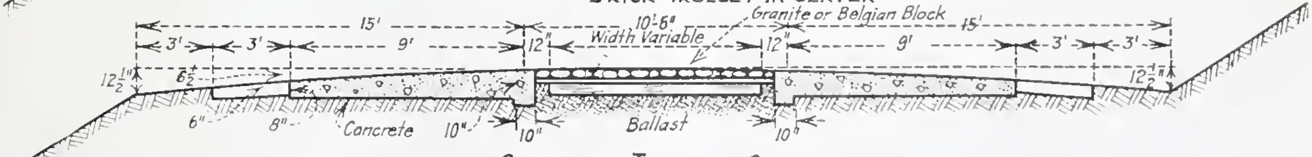

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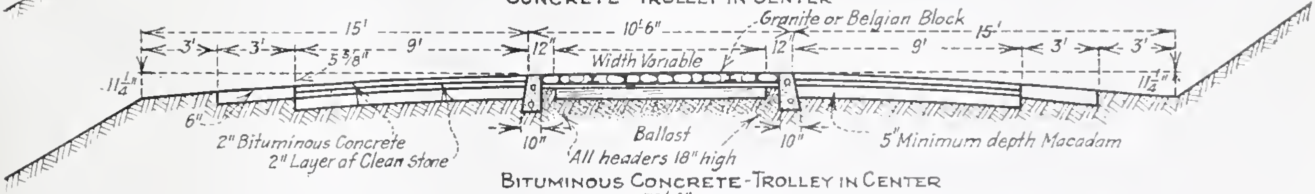

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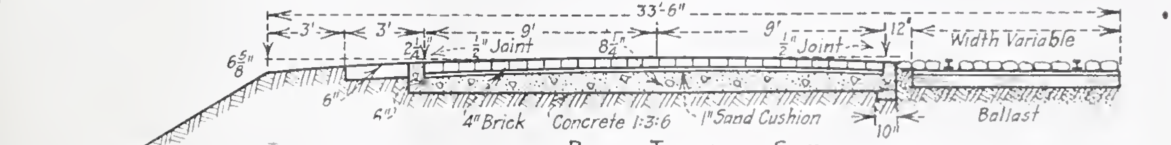
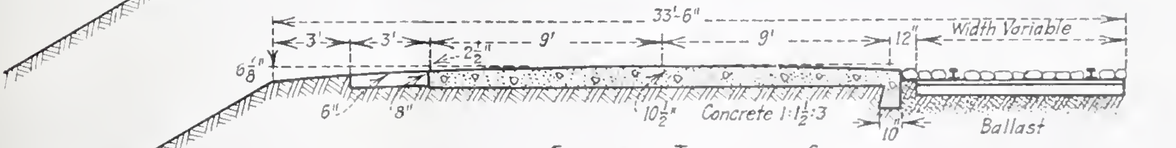


BRICK-TROLLEY AT SIDE



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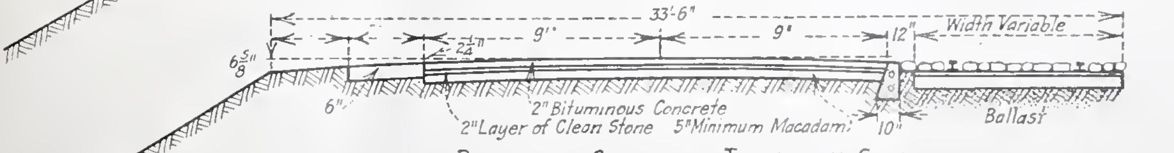

BITUMINOUS CONCRETE-TROLLEY AT SIDE

The Organization of Efficient Concrete Road Construction Gangs*

By HALBERT P. GILLETTE,
Editor, Engineering and Contracting, Chicago.

This question is often asked of the man who has made an enviable financial record: "What is the secret of your success?" If he is not a man given to analyzing his methods, he is apt to reply with some generalization that is too broad to be serviceable to others, such as "Hard work is the secret," or "Strict honesty," or "Attention to details," and the like.

The fact is that there is no single "secret" of success, whether it be winning battles or building roads. Success is usually a simple result, but it is never attained by a single "open sesame." It is the outcome of the judicious application of many separate factors. So, in discussing how to organize construction gangs with which to build roads economically, we must dismiss at once the idea that there is any one way that is invariably successful in accomplishing the desired minimum cost.

On the other hand, although different organizations are needed for different conditions, there are a few general principles of organization applicable under any condition; and there are many subsidiary principles of organizaton applicable under more specific conditions. In addition to such principles, there is an almost limitless number of "tricks of the trade" that can be profitably applied only under very specific conditions.

To illustrate, it is a good general rule of organization that each construction gang should be composed of men of the same nationality. This broad rule may be broadened to read: Other factors being equal, the best construction gang is one composed of individuals having similar temperament and habits. Experience has taught us that this is a sound rule of very broad application. It holds as true of sewer work as of road work, of military units as of a squad of religious revivalists.

There are, however, "secrets" of organization success that are of somewhat narrower application. Thus it is a good rule to make one of a gang of shovelers the leader or pace maker, that is, a sort of "working foreman." Such a man should be more ambitious than the rest, and close mouthed enough not to state his weekly bonus to his fellows. If paid a bonus of $5 to $10 a week above the average wage, a good "working foreman" will set a pace that will decidedly increase the output of a shoveling gang. This principle of employing "working foremen" is one that was formerly more commonly applied than at present. It has lost none of its efficacy.

As an example of a minor "trick of the trade," or economic method of limited application, the following is offered. Let it be the duty of one man to "spot" every load of stone (or gravel) and sand, instructing the driver exactly where to dump it. This man may also have other functions to perform, such as setting the side-boards or "rules" trimming subgrade, or what not. But even if he were to do nothing else than place the aggregate properly he would save more than his wages. It is not uncommon to see piles of stone or gravel shoveled off the roadbed onto the shoulders, because loads of aggregate were dumped too close together. It is equally common to see loads too far apart, resulting in long hauls for wheelbarrows and the subsequent bringing in of extra wagon loads of materials under adverse hauling conditions.

Closely allied to this "trick" of having a man "spot" each load is having a man regulate the size of loads at the point of loading. The size of wagon or truck loads may vary 5 to 10 per cent unless it is some one's duty to watch the loading. Standard loading is highly desirable, as a little consideration will show. But by standard loading, I do not mean an unvarying size of load throughout an entire job. I mean a standard size for giving hauling conditions. If the earth over which the load is hauled is hard, and if the grades are easy, the standard load should be large. Under more difficult hauling conditions, it should be smaller. But in every case, the standard load for given conditions should be adhered to rigorously. This can be accomplished only by making it the special duty of some one to watch the loading of wagons or trucks.

Reviewing the three examples just given, we have (1) the broad principle of selecting similar individuals for each gang. (2) the narrower principle of having a "working foreman" for shoveling gangs, and (3) the still narrower construction methods of "spotting wagons" and of "standard sizing of loads."

In this connection it may be well to point out that men of college education are apt to be unduly impressed by what are called "general principles." Let a "law of nature" be announced and most college men are prepared to kowtow; but let a "trick of the trade," or a "construction method" be announced and they may not deign to lift an eyebrow. I am convinced that this false attitude toward the humble "tricks of the trade" accounts largely for the failure of many a college engineer to make a good superintendent of construction. However, engineering colleges are rapidly improving and fewer students are being graduated under the false impression that a knowledge of "tricks of the trade" is less important than a knowledge of broad principles.

The only difference between the worth of a broad principle and of a special economic method, or "trick," lies in the number of cases to which each is applicable. Hence it may happen that it is worth more to a road-builder to know that it pays to "spot" wagon loads than to know Newton's laws of gravitation.

A manager of concrete road gangs should be acquainted not only with the general principles of scientific management but with a great many specific methods of transporting, mixing, placing and surfacing concrete. The larger his store of knowledge of methods, the more likely it is that he will select an economic combination of methods for any given job. Hence the importance of storing the mind with published methods and hints relating to road work. This seems perfectly self-evident, yet it is a fact that the majority of construction managers add very little to their knowledge except through personal observation.

It also seems self-evident that gangs should be so organized that all the workmen will be kept uniformly busy. Yet is it very common to see a large percentage of time wasted because of poor co-ordination. This is attributable to the fact that the manager does not know what constitutes a fair day's work for a man engaged in each of the separate processes or duties. Thus, if the manager does not know how many cubic yards of sand a workman should load per hour into barrows, and how many cubic yards he should be able to wheel a distance of 100 ft. per hour, he cannot accurately assign the right number of sand loaders and wheelers to a mixer having a given hourly capacity of concrete.

For the most accurate studies of gang organization, it may be desirable to time every single process and every minute delay, using a stop watch for the purpose. Such great refinement is not ordinarily needed on construction work. But it is desirable to know the average hourly output of good workmen on each class of work under any given conditions. To do this, any given class of work should be analyzed into two general parts, namely (1) the parts that do not vary materially on different jobs, and (2) the parts that vary on different jobs. Thus, in hauling sand with wagons, the team time lost in loading and dumping each load is quite uniform, but the time spent in hauling depends on the length of the haul. Hence the time can be expressed as a constant number of minutes (say 10 minutes) per load plus a minute per 100 ft. of distance between the loading and the dumping points. With such a rule in his head, a manager is able to assign the proper number of teams to the hauling of sand. Similarly for wheelbarrow work, or for any other kind of hauling.

Having thus scientifically selected the proper number of men and teams for each duty, the manager should watch them carefully to ascertain whether there is any "soldiering" or unnecessarily lost time, either because too many or too few men have been assigned to a given task. If too many men have been assigned, say, to loading sand, the manager can usually ascertain the fact by watching them for half an hour. If too few men have been assigned to sand handling, the other men will be delayed, and this can be readily ascertained by observing the other man. So an experienced manager need not necessarily know the average time required to perform each operation, but, by a "cut and try" method, he can distribute his men with considerable accuracy. Nevertheless, even an experienced manager will effect a better organization of his forces if he knows what to expect of a man on each kind of work under given conditions.

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*From the June Concrete Highway Magazine.

I have found, as have other road builders, that the timing of each separate operation and each cause of "lost time" is one of the most effective means of improving the organization of men. Lost time is the greatest source of lost profits on road work. On most concrete road jobs the average daily progress of a mixer gang for a month is about half what it is during a day when everything runs smoothly. Extra parts and duplicate machines would do away with most of this lost time. But managers usually do not keep a detail record of all lost time and the causes. Hence they usually fail to realize the true economy of having spare parts, spare pumps, duplicate pipe lines, etc. For the same reason, they usually fail to realize that it pays to have spare men—men able to fill a gap or ready to attend to a breakdown or to shift a plant with expedition. A small emergency gang of "Jacks of all trades" will usually earn their wages many times over by reducing delays from breakdowns, plant shifting, shorthanded crews, etc.

The average workmen likes to do only one class of work. If his job is to finish a concrete surface, he resents being required to load a wheelbarrow. This is easy to understand where a skilled man is required to do unskilled work. Why a common laborer should resent being shifted from one class of unskilled work to another class is not so clear, but it is a fact. A wheelbarrow man dislikes turning his hand to pick and shovel work, for example. But there are a few men who seem to enjoy frequent changes, and will gladly do anything from grubbing roots to shoeing a horse, provided they are not kept at one thing very long. This is the type of man for an emergency gang. Every large road job should have such a gang.

In a brief article on a big subject it is impracticable to do more than throw out a few suggestions. Of the few here offered, there is one, however, that will prove profitable to every manager of road gangs. It is this: Keep a note book in which you enter a memorandum of every "trick of the trade" that you see, hear, or read. Number each of these "hints" serially. Read them over at intervals. You will ultimately have nearly every one of several hundred "hints" committed to memory. And as your stock of memorized "hints" grows, you will find it progressively easier to remember new "hints." Most men make the mistake of regarding the brain as a store house of limited capacity for memorized facts. Its capacity is practically limitless; and, curiously enough, the greater the number of facts of a given class a man memorizes, the stronger does his memory grow for facts of that class. College trained engineers are particularly prone to avoid memorizing details. They argue that they need remember only general principles and that they can look up published details when necessary. In practice, however, they seldom look up published details in a thorough going manner, partly because they haven't the sources of reference at hand, and partly because published indexes are wholly unsatisfactory for the purpose of finding such details.

In reading biographies and sketches of famous men, it is worth noting that such men are so frequently credited with having an astonishing command of memorized data relating to their specialty. James J. Hill, "the empire builder," had a memory for details of railway operating and construction costs that was amazing. He was a genius as an organizer and promoter. Certainly, his feats of memory were not merely incidental to his success, but, in large measure, accounted for it. If we cannot all be prodigies like Jim Hill, at least we can profit by using his methods.

North Carolina State College Will Have Highway Engineering Course.—To meet the demand for competent highway engineers in North Carolina, the State College has created a new department of highway engineering. The present demand for such a course is emphasized by the fact that all of this year's graduates in civil engineering are going into state highway work. Captain Harry Tucker, 105th Engineers, who recently returned from France, will head the new department, as associate professor of highway engineering. This department will be a subdivision of the civil engineering department. The first three years of the course will be practically identical with that of civil engineering, but in the senior year the subjects of least importance will be omitted or abridged and the resulting time devoted to specialized courses in highway engineering.

How to Obtain Best Results in Constructing 1-Course Bituminous Macadam

Bituminous macadam possesses the advantages of being comparatively simple of construction, low in first cost, and simple in maintenance. There are several varieties of this type of pavement, but all are very nearly the same in essentials. In all, broken stone is laid, rolled more or less, and the voids filled or impregnated with bitumen and the surface finally covered with smaller particles of mineral and finished off with or without a seal coat. Of the several varieties the 1-course type is the simplest to specify and lay, and presents the least opportunity for difficulties. A considerable mileage of this type has been laid by the Massachusetts Highway Commission. In a recent issue of Public Roads, Mr. F. C. Pillsbury, Division Engineer of the Commission, describes the methods that have proved most successful in that state. The matter following is taken from his paper.

The actual construction of the pavement may be described as follows:

On a suitable foundation is laid a base or bottom course of broken stone partially bound like waterbound macadam, on which is laid the top course or bituminous macadam.

The foundation must, of course, be such that it will be suitable at all times of the year. The base course must be sufficiently strong to reduce to a minimum, or practically prevent, vertical movement of the stones in the bituminous macadam, and the bituminous macadam itself should be so laid that the bitumen will surround all the particles of the stone, practically filling the voids and sealing the surface.

The bituminous macadam to attain this success must be laid according to approved methods. Bituminous macadam does not give good results when it is not so laid; that is, good results may not be expected from bituminous macadam when the materials or methods employed are not what they should be. There is frequently a complaint of the waviness of this type of pavement, but it need not be built so as to be wavy; sometimes it becomes rutted or depressions or holes develop, but this can be avoided if the work is done properly.

Drainage and Foundation.—It is a common error to lay the foundation of large cobblestones or broken fragments of rock in climates subject to frost action directly on soft clay quicksand or loamy soils, because these stones work up and down under traffic and frost action, the voids between them become filled with the fine earth beneath, and ultimately, frequently in only a short time—sometimes less than the winter season—the mud thus reaches right up to the bottom of the macadam. Of course, moisture accompanies mud, and there is a very unstable foundation which is more or less constantly in motion except when frozen solid or when thoroughly dried out. Finally, the bituminous macadam crust separates as it bends under traffic, and as it breaks apart in this way moisture from beneath works into the cracks or interstices at the bottom and from the top. Then destruction, more or less extensive, is only a question of time.

What should have been done is to lay a foundation of clean gravel or even clean sand or fine broken stone in preference to the large stone fragments, or if such stone fragments must be used because there is a scarcity of other material, they should be broken up much smaller, say, about 3 in. and less. Of course, when necessary the ground water should be removed with adequate drainage. These results obtain whenever the base is laid on material that will be affected by moisture or frost sufficiently to cause much movement. Moisture working up from beneath always shortens the life of any surface, and, strange to say, partly because the bituminous surface is such a simple one to lay ordinarily, there seems to be an idea that it is not worth while to lay a proper base and foundation. It is probable that more than half the failures are due to this reason. Success is impossible unless the foundation is correct.

Construction of the Bottom Course or Base.—The bottom course should be of sufficient strength to hold up the top course; that is, to support it so that it will not rut under traffic and will not be affected by any movement of the foundation or soil beneath the base. This is essential. The size of the stones in the base may vary from ½ to 3 in. or even 4 in., provided there is a reasonable proportion of the larger with the smaller size. It would not be good practice to use over 50 per cent under 1¼ in. in size, but would do no harm if they were all 3 in. large. Then this bottom course must be very carefully spread and rolled so as to be uniformly parallel with the finished surface. This provides for a uniform thickness of the bituminous macadam. In the base it is well to partially bind it with sand, fine screened gravel, or stone screenings, using the steam road roller, and, if necessary, sprinkling occasionally with water. But this bottom course should not be so rolled as to be absolutely firm; it is better for it to be slightly loose because this looseness will permit the taking up of the very slight unevenness unavoidable in spreading the broken stone of the top course, and thus resulting in a smoother surface. In other words, this bottom course should not be too rigidly bound, as is sometimes done, with the usually accompanying result of a slightly uneven finished surface in the road.

The Top or Bituminous Course.—This brings us to the bituminous macadam itself, the materials of which are the stone and the bitumen.

The broken stone should not be so soft as to crush under the roller so as to fill the voids before the bitumen is applied. When this occurs the bitumen does not fill the voids, and from such spots slack of bitumen there may arise two bad results. There may be a wave, due to the surplus of bitumen on top because it could not penetrate down into the stones, or there may be a breaking up of the surface because the stones have nothing to bind them together. The best results are obtained when hard rocks are used, such as trap rocks. There are many localities where it is impossible to get trap rock or stone with a coefficient of wear sufficiently high to obtain results required. In such cases bituminous macadam should not be laid. For ordinary traffic such as exists on most of the main through state roads bituminous macadam can be laid economically, provided broken stone has a coefficient of not less than about 15, and provided the bitumen is of suitable quality. The size of the broken stone should be 1¼ to 2½ or 3 in., according to the thickness of the course. A top course 2 in. thick may be obtained with the 2½-in. stone, while a 3-in. course may be obtained with the larger size. If the traffic is very heavy it is better to lay the thicker course with the larger stones.

The quantities of the bitumen for the 2-in. road are 1¾ gal. for the first application and ½ gal. for the second, or seal coat, and should be very closely followed. For a 3-in. road these quantities will be increased about ¾ gal. in the first application, although this depends somewhat upon the hardness of the stone and the weight of the traffic. If the stone is very hard it would be better to use a little more bitumen, as the voids will be greater with the harder stone. For the same reason, if the traffic is light, there may be a little more bitumen used than when the traffic is heavy. The quantity should not vary more than ½ gal. per square yard on a 3-in. road and ¼ gal. per square yard on a 2-in. road.

Workmanship.—The general process of laying a bituminous macadam is such a simple one in theory that nearly everyone considers it unnecessary to go into the details of construction carefully and does not realize the many little things that have to be done with the greatest care to get good results. This is a matter of good workmanship. Carelessness in any respect at any time is sure to lead to imperfect results. It may be that specifications are not sufficiently complete to cover all these details.

The work of laying of the top course of the bituminous macadam consists of the following operations, in the order in which they occur:

(1) Spreading the large broken stone.

(2) Rolling of this stone.

(3) Correction of imperfections in spreading or any unevenness developing while rolling.

(4) The first application of the bitumen.

(5) The first light spreading of the peastone, brooming around of the first spreading of the peastone so as to have it absolutely uniformly distributed that there may not be an accumulation in any depression which may have occurred under the distributor or for any other reason, so that there will be absolutely just a very thin sprinkling for the first spreading over the entire surface to be rolled.

(6) The second rolling.

(7) Sweeping off of the surplus peastone, dust, etc., in preparation for the second application of bitumen or seal coat.

(8) The second application of bitumen or seal coat.

(9) The final covering of peastone, to be very uniform and broomed about after being spread by the shovels to insure uniformity in thickness.

(10) The final or third rolling—and here it should be stated that the second rolling is the most important.

Each one of these operations in itself is of sufficient importance to warrant some further mention, and they are taken up in detail as follows:

Spreading the Large Broken Stone.—Broken stone will be brought in either on cars or trucks, and if possible should be dumped on dumping boards and spread with shovels, or if the stone should contain much dirt or dust, with forks, not with the large rakes sometimes used for this purpose; or stone may be spread from piles where it has been previously dumped on the roadside, but this is not the best practice. Greatest care must be taken to spread the stone with absolute uniformity. If dumping boards are not used, the entire pile of stone which has been dumped should be rehandled to provide for the removal of any accumulation of dust or particles of stone too fine, and prevent unevenness which is almost sure to follow if the stone is not rehandled.

Rolling of This Stone.—This should, of course, be done carefully and with more or less intensity, according to the hardness of the stone. It should not be sufficient to crush the stone and need be only enough to lay it with sufficient firmness to prevent material tracking or rutting when the spraying machine passes over it in the first application of the bitumen. Slight tracking by wheels of the spraying machine will roll out.

Corrections of Imperfections in Spreading or Rolling.—Any depressions or bunches which develop during this first rolling should be very carefully eliminated by adding more stone to fill the depressions or by the pulling off into the depressions stone from spots where there is too much. It is at this time, while rolling, that any unevenness in the surface should be corrected, as it is extremely difficult to correct it after the bitumen has been applied. It is frequently necessary to correct the slight depressions by placing only a few pieces of broken stone in them. The man having charge of this spreading should, if necessary, get down on his hands and knees and search for the inequalities in correcting them.

The First Application of the Bitumen.—This is sometimes done successfully by hand pouring, but never as well as when properly applied by a suitable pressure distributor. When poured by hand it should always be done longitudinally with the direction of the traffic, never across the road, for there will always be, when hand poured, more bitumen where one pouring meets another, particularly when asphalt is used. Under wear of traffic slight projections on the surface occur where there is more bitumen. For the same reason it is much better not to apply from a single nozzle from the pressure distributor but from a single or double row of nozzles. The applications from the pressure distributor may be of any width desired, usually from 7 to 10 ft., so that on the ordinary road two applications will cover the entire width, but on wider surfaces there may be additional applications. Where, however, there are irregularities in the widths, the areas outside of the regular width may be penetrated with a single nozzle or by hand pouring.

In some cases bitumen may be heated at a single plant and sent out in motor-drawn distributors, sometimes as far as 30 or 40 miles, and successfully applied. In the absence of such central heating plants the bitumen usually is delivered on the work in barrels and heated in kettles. It is much better to have kettles with a heating capacity of about 400 gal. Two or three such kettles will provide for the application of from 1,500 to 2,500 gal. per day, and one spraying machine will distribute this quantity of bitumen. Care should be taken in heating not to burn. Bitumen should be strained when passing from the kettles into the distributor as well as when being taken into the distributor at the central plant, otherwise there will be particles of foreign substances getting into the distributors and clogging the nozzles. This causes imperfect application. Asphalt always should be heated to not less than 300° F. not more than 400° F., and tar to not less than 225° F.

Just before the bitumen is applied from the distributor the outlets from the distributor and the nozzles should be tested out carefully to see that they are all free. There always should be a trough on hand in which any drippings from the nozzles may be caught instead of being allowed to fall on the road, as these drippings would form bunches in the surface. Care should be taken not to lap over a previous application. This may be done by laying rough paper covered with sand or stone dust, for 5 or 6 ft. back from the end of the previous application; or even sand alone, if paper is not available. Then a flying start may be made and the distributor opened just before reaching the end of the previous application. The overlapping bitumen then can be removed by taking off the paper and sand.

When the load of bitumen has been distributed the distributor should not be allowed to go on with the valves open, thus tracking bitumen along over the road, but as soon as the full spray ceases the operator should close the valves instantly and men should be on hand with the trough to catch the drippings. After each load has been distributed the pipes of the distributor should be blown out and cleaned out before it is refilled.

The actual operation of the application of a tank load from the distributor occupies only a few minutes, provided there is no stoppage of the nozzles or difficulty in the operation, so that there should be no hesitation about taking all the time necessary to insure the free working of the nozzles before commencing the application, and taking every precaution between applications to obtain the same result. Some one skilled always should be on hand to see to it that the application of the bitumen is perfectly done because if not perfectly done the results are going to be imperfect and to that extent a failure.

The First Light Spreading of the Peastone.—The first light spreading of the peastone after the first application of bitumen is for the purpose of filling the surface voids and providing a sufficient covering to permit the roller to pass over without sticking to the bitumen. The least quality of peastone that will accomplish this purpose is best. Any more than enough is superfluous and a waste, as it interferes somewhat with the compression of the stone and all surplus has to be swept off before the seal coat is applied. This spreading probably will consist of about 5 lb. to the square yard. It never should be allowed to be any thicker in one place than another, and should be so thin that the bituminous surface below shows through it everywhere.

The Second Rolling.—The roller may be the usual 10-ton steam road roller or heavier, much better heavier, and when asphalt is used with trap rock should weigh not less than 15 tons, as the asphalt cools quickly and the stone then compresses with difficulty. It is economy to use a heavy roller because the results are accomplished in much less time and the expense of operating the heavy roller is very little greater. Best results with asphalt can be obtained only with a heavy roller. This second rolling can not be overdone unless the ground beneath develops a softness and depressions begin to occur. Sometimes after heavy rain the ground beneath does become soft and then rolling has to be done with care, if not postponed altogether until after the ground is dried out. Should any distinct unevenness occur which can not be rolled out during this second rolling, it should be corrected by removing such imperfect area altogether and replacing neatly with new broken stone and new bitumen by the methods already outlined.

Sweeping Off of the Surplus Peastone, Dust, Etc.—After the second rolling and before the seal coat is applied all loose particles of dust, stone and dirt should be carefully and completely swept off. If allowed to remain they will cause a separation between the second application of bitumen and that in the bottom course, so that the second application may peel off.

The Second Application of Bitumen.—The second application of the bitumen, forming the seal coat, should be made with great care, in the same way as to method as the first application, the same precautions being taken in heating, loading the spraying machine, and applying. When the seal coat is hand poured it should be done with even greater care than the first pouring, and a sufficient number of men should be on hand with rubber squeegees or rattan push brooms to spread the surplus bitumen around immediately after pouring, so as to carry a uniform quantity everywhere.

The Final Covering of Peastone.—Immediately after the second application of asphalt it should be covered with a final coating of peastone, the quantity of which will be about 20 lb. to the square yard or more, sufficient to take up the asphalt of the seal coat and prevent it from sticking to the roller or wheels of vehicles. This is frequently spread carelessly. It should never be dumped on the road surface before spreading, but should be either spread from a dumping board or from carts or piles at one side, and should be broomed after spreading before it is rolled.

The rolling of the final covering of peastone should ordinarily be as intense as the rolling after the first application of bitumen, but if for any reason it has been impossible to secure the desired results with the first rolling, the second rolling should be done so as to remedy any defects.

If all the conditions are carefully studied and met by proper treatment, the bituminous macadam will be successful. The chief objection, if it may be so called, in the perfect bituminous macadam, lies in its slipperyness for horses, but nearly all first-class bituminous pavements are slippery in this respect and when seriously so there should be a slight covering of sand spread occasionally, the cost of which is very little.

Causes of Waviness.—Waviness may be due to using a small size of stone in the bituminous surface. This is quite sure to follow the use of stone which does not exceed 1½ in. in largest dimensions, which some of us know as No 2 stone: in other words, this size of stone when used will almost invariably wave sooner or later under heavy or medium traffic. Under very light traffic the stone will stay in place and not wave unless there is a surplus of bitumen. Where the smaller stones are used the voids will be smaller and a smaller quantity of bitumen should be used. There should be fully ½ gal. less than when stone of the larger size is used.

With the large-sized stone, even if there is a surplus of bitumen, there will be no movement of the stone nor waving of the surface unless there may be such a surplus of bitumen on top of the stone that it has the appearance of waving. But this surplus can be removed with grub hoes or hot shovels and should be taken off immediately after it has been put on during construction. If the weather at that time should be too cool it will not be very serious if left on the road until warm weather comes again.

Best Time for Laying.—There is no reason why this type of bituminous macadam will not give good results in any climate, but it should not be laid in the late fall in the northern states, as the bitumen cools in place so quickly that it prevents proper compacting of the stone. There have been instances where the work was done late and it was necessary to apply a second seal coat on account of the openness of the surface, leading to considerable additional expense

In spite of every precaution, as in the case of any pavement, some imperfections may sometimes develop. Frequently miles of road are built without any of these imperfections developing: at other times when the men are not fully experienced or will not take proper care after the road has been open to traffic, small spots will appear where there does not seem to have been sufficient bitumen and the stone starts to ravel. Examination has shown that this frequently is due to the presence of a foreign substance on the surface when the bitumen was applied. Care should be taken to see that before bitumen is applied there is nothing in the stone which would prevent it from penetrating the voids. In the fall of the year, when leaves are dropping from the trees, it is sometimes necessary to have a gang of 10 men or more taking the leaves off the surface of the road immediately before the application of the bitumen.

Usually imperfections of workmanship will develop within about 12 months of the time the work is done, and they may be corrected by patching, which should be done just as the work was done in the first place, except that bitumen may be hand poured, but stone and bitumen of the same kind, and the steam roller should be used.

General Conclusions Regarding Convict Labor.—Arizona has been employing convicts since 1909 on the construction of state roads and bridges. The general conclusions regarding the class of labor are summarized as follows by Mr. B. M. Attwood, State Engineer: Such labor is capable of producing work of good quality, both in highway work and in the construction of reinforced concrete bridges, and costs are low and escapes few. It appears, however, that such convict labor is more dependent on the quality of its leadership than is free labor, and that a convict camp under poor management may easily become a source of great annoyance, of danger to the public, of loss in money, and may fail to produce any work of value to the State. The cost of work done by convict labor under the Arizona laws has been approximately two-thirds the cost of similar work done under the day labor system.

A Page of Useful Tables for the Highway Engineer

(These tables are used by the engineers of the State Highway Department of Connecticut.)

TONS OF STONE (LOOSE MEASURE) PER 100 LIN. FT. OF ROAD.

Weight, 2,300 lb. per cubic yard.

Width of metal course.	Depth								
	2″	3″	4″	5″	6″	7″	8″	9″	10″
8′	5.679	8.519	11.358	14.197	17.037	19.876	22.716	25.555	28.395
10′	7.099	10.648	14.197	17.747	21.296	24.846	28.395	31.944	35.494
12′	8.519	12.778	17.037	21.296	25.555	29.815	34.074	38.333	42.593
14′	9.938	14.907	19.876	24.846	29.815	34.784	39.753	44.722	49.691
16′	11.358	17.037	22.716	28.395	34.074	39.753	45.432	51.111	56.790
18′	12.778	19.167	25.555	31.944	38.333	44.722	51.111	57.500	63.889
20′	14.197	21.296	28.395	35.494	42.593	49.691	56.790	63.889	70.988

Weight, 2,400 lb. per cubic yard.

Width of metal course.	Depth								
	2″	3″	4″	5″	6″	7″	8″	9″	10″
8′	5.926	8.889	11.852	14.815	17.778	20.741	23.704	26.667	29.630
10′	7.407	11.111	14.815	18.519	22.221	25.926	29.630	33.333	37.037
12′	8.889	13.333	17.778	22.222	26.667	31.111	35.556	40.000	44.441
14′	10.370	15.555	20.741	25.926	31.111	36.296	41.481	46.667	51.852
16′	11.852	17.778	23.704	29.630	35.556	41.481	47.407	53.333	59.259
18′	13.333	20.000	26.667	33.333	40.000	46.667	53.333	60.000	66.667
20′	14.815	22.222	29.630	37.037	44.444	51.852	59.259	66.667	74.074

Weight, 2,500 lb. per cubic yard.

Width of metal course.	Depth								
	2″	3″	4″	5″	6″	7″	8″	9″	10″
8′	6.173	9.259	12.346	15.432	18.518	21.604	24.691	27.778	30.864
10′	7.716	11.574	15.432	19.290	23.148	27.006	30.864	34.722	38.580
12′	9.259	13.889	18.518	23.148	27.778	32.407	37.037	41.667	46.296
14′	10.802	16.204	21.605	27.006	32.407	37.809	43.210	48.611	54.012
16′	12.346	18.518	24.691	30.864	37.037	43.210	49.382	55.555	61.728
18′	13.889	20.833	27.778	34.722	41.667	48.611	55.555	62.500	69.444
20′	15.432	23.148	30.864	38.580	46.296	54.012	61.728	69.444	77.160

Weight, 2,600 lb. per cubic yard.

Width of metal course.	Depth								
	2″	3″	4″	5″	6″	7″	8″	9″	10″
8′	6.420	9.630	12.839	16.049	19.259	22.469	25.679	28.889	32.099
10′	8.025	12.037	16.049	20.062	24.074	28.086	32.099	36.111	40.123
12′	9.630	14.444	19.259	24.074	28.889	33.704	38.518	43.332	48.148
14′	11.235	16.852	22.469	28.086	33.704	39.321	44.938	50.555	56.173
16′	12.839	19.259	25.679	32.099	38.518	44.938	51.358	57.778	64.197
18′	14.444	21.667	28.889	36.111	43.333	50.555	57.778	65.000	72.222
20′	16.049	24.074	32.099	40.123	48.148	56.173	64.197	72.222	80.247

Weight, 2,700 lb. per cubic yard.

Width of metal course.	Depth								
	2″	3″	4″	5″	6″	7″	8″	9″	10″
8′	6.667	10.000	13.333	16.667	20.000	23.333	26.667	30.000	33.333
10′	8 333	12.500	16.667	20.833	25.000	29.167	33.333	37.500	41.667
12′	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
14′	11.667	17.500	23.333	29.167	35.000	40.833	46.667	52.500	58.333
16′	13.333	20.000	26.667	33.333	40,000	46.667	53.333	60.000	66.667
18′	15.000	22.500	30.000	37.500	45.000	52.500	60.000	67.500	75.000
20′	16.667	25.000	33.333	41.667	50.000	58.333	66.667	75.000	83.333

Weight, 2,800 lb. per cubic yard.

Width of metal course.	Depth								
	2″	3″	4″	5″	6″	7″	8″	9″	10″
8′	6.914	10.370	13.827	17.284	20.741	24.198	27.654	31.111	34.568
19′	8.642	12.963	17.284	21.605	25.926	30.247	34.568	38.889	43.210
12′	10.370	15.556	20.741	25.926	31.111	36.296	41.481	46.667	51.852
14′	12.099	18.148	24.198	30.247	36.296	42.346	48.395	54.444	60.494
16′	13.827	20.741	27.654	34.568	41.481	48.395	55.309	62.222	69.136
18′	15.556	23.333	31.111	38.889	46.667	54.444	62.222	70.000	77.778
20′	17.284	25.926	34.568	43.210	51.852	60.494	69.136	77.778	86.420

GALLONS OF OIL PER 100 LIN. FT. OF ROAD.

Width in feet.	Number of gallons per square yard								
	.25	.50	.667	.75	1.00	1.25	1.50	1.75	2.00
8	22.22	44.44	59.26	66.66	88.89	111.11	133.33	155.55	177.78
10	27.77	55.56	74.08	83.33	111.11	138.88	166.67	194.44	222.22
12	33.33	66.67	88.89	100.00	133.33	166.66	200.00	333.33	266.66
14	38.89	77.78	103.71	116.67	155.56	194.45	233.33	272.23	311.12
16	44.44	88.89	118.52	133.33	177.78	222.22	266.67	311.11	355.56
18	50.00	100.00	133.33	150.00	200.00	250.00	300.00	350.00	400.00
20	55.56	111.11	148.15	166.67	222.22	277.78	333.33	388.88	444.45

AREA OF WATERWAY, MYER'S FORMULA: AREA OF WATERWAY IN SQ. FT. = C × √DRAINAGE AREA IN ACRES.

Drainage area. Sq. miles.	Drainage area. Acres.	Flat. C = 1.	Rolling. C = 2.	Hilly. C = 3.	Mountainous. C = 4.
1	640	25.30	50.60	75.89	101.19
2	1,280	35.78	71.55	107.33	143.11
3	1,920	43.82	87.64	131.45	175.27
4	2,560	50.60	101.19	151.79	202.38
5	3,200	56.57	113.14	169.70	226.27
6	3,840	61.97	123.94	185.90	247.87
7	4,480	66.93	133.87	200.80	267.73
8	5,120	71.55	143.11	214.66	286.22
9	5,760	75.90	151.79	227.69	303.58
10	6,400	80.00	160.00	240.06	320.00
15	9,600	97.98	195.96	293.94	391.92
20	12,800	113.14	226.27	339.41	452.55
25	16,000	126.49	252.98	379.47	505.96
30	19,200	138.56	277.13	415.69	554.26
35	22,400	149.67	299.33	449.00	598.66
40	25,600	160.00	320.00	480.00	640.00
45	28,800	169.71	339.41	509.12	678.82
50	32,000	178.89	357.77	536.66	715.61
60	38,400	195.96	391.92	587.88	783.84
70	44,800	211.66	423.32	634.98	846.64
80	51,200	226.27	452.55	678.82	905.10
90	57,600	240.00	480.00	720.00	960.00
100	64,000	252.98	505.96	758.95	1,011.93
110	70,400	265.33	530.66	795.99	1,061.32
120	76,800	277.13	554.26	831.38	1,108.51
130	83,200	288.44	576.89	865.33	1,153.78
140	89,600	299.33	598.67	898.00	1,197.33
150	96,000	309.84	619.68	929.52	1,239.36
160	102,400	320.00	640.00	960.00	1,280.00
170	108,800	329.85	659.70	989.54	1,319.39
180	115,200	339.41	678.82	1,018.23	1,357.64
190	121,600	348.71	697.42	1,046.14	1,394.85
200	128,000	357.77	715.54	1,073.31	1,431.08

WEIGHTS AND AREAS OF SQUARE AND ROUND BARS AND CIRCUMFERENCES OF ROUND BARS.

1 Cu. Ft. of Steel weighs 489.6 lb.

Thickness or diameter in inches.	Weight of square bar 1 ft. long.	Weight of round bar 1 ft. long.	Area of square bar in sq. in.	Area of round bar in sq. in.	Circumference of round bar in in.
1/16	.013	.010	.0039	.0031	.1963
⅛	.053	.042	.0156	.0123	.3927
3/16	.119	.094	.0352	.0276	.5890
¼	.212	.167	.0625	.0491	.7854
5/16	.333	.261	.0977	.0767	.9817
⅜	.478	.375	.1406	.1104	1.1781
7/16	.651	.511	.1914	.1503	1.3744
½	.850	.667	.2500	.1963	1.5708
9/16	1.076	.845	.3164	.2485	1.7671
⅝	1.328	1.043	.3906	.3068	1.9635
11/16	1.608	1.262	.4727	.3712	2.1598
¾	1.913	1.502	.5625	.4418	2.3562
13/16	2.245	1.763	.6602	.5185	2.5525
⅞	2.603	2.044	.7656	.6013	2.7489
15/16	2.989	2.347	.8789	.6903	2.9452
1	3.400	2.670	1.0000	.7854	3.1416
1/16	3.838	3.014	1.1289	.8866	3.3379
⅛	4.303	3.379	1.2656	.9940	3.5343
3/16	4.795	3.766	1.4102	1.1075	3.7306
¼	5.312	4.173	1.5625	1.2272	3.9270
5/16	5.857	4.600	1.7227	1.3530	4.1233
⅜	6.428	5.049	1.8906	1.4849	4.3197
7/16	7.026	5.518	2.0664	1.6230	4.5160
½	7.650	6.008	2.2500	1.7671	4.7124
9/16	8.301	6.520	2.4414	1.9175	4.9087
⅝	8.978	7.051	2.6406	2.0739	5.1051
11/16	9.682	7.604	2.8477	2.2365	5.3014
¾	10.41	8.178	3.0625	2.4053	5.4978
13/16	11.17	8.773	3.2852	2.5802	5.6941
⅞	11.95	9.388	3.5156	2.7612	5.8905
15/16	12.76	10.02	3.7539	2.9483	6.0868
2	13.60	10.68	4.0000	3.1416	6.2832

TABLE FOR COMPUTATION OF EARTHWORK—VOLUME OF 50 FT. SECTIONS IN CU. YD. FOR SUM OF END AREAS

Sum of E. A. Sq. ft.	Volume Cu. yd.	Sum of E. A. Sq. ft.	Volume Cu. yd.	Sum of E. A. Sq. ft.	Volume Cu. yd.	Sum of E. A. Sq. ft.	Volume Cu. yd.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	0	27	25	54	50	81	75	.000	093	.185	.278	.370	.463	.556	.648	.740	.833
1	*0	28	*25	55	*50	82	*75	.926	1.018	1.111	1.204	1.296	1.389	1.481	1.574	1.667	1.759
2	*1	29	*26	56	*51	83	*76	.852	.944	1.037	1.130	1.222	1.315	1.407	1.500	1.503	1.685
3	*2	30	*27	57	*52	84	*77	.778	.870	.963	1.056	1.148	1.241	1.333	1.426	1.518	1.611
4	*3	31	*28	58	*53	85	*78	.704	.796	.889	.981	1.074	1.167	1.259	1.352	1.444	1.537
5	*4	32	*29	59	*54	86	*79	.630	.722	.815	.907	1.000	1.093	1.185	1.278	1.370	1.463
6	*5	33	*30	60	*55	87	*80	.556	.648	.741	.833	.926	1.019	1.111	1.204	1.296	1.389
7	6	34	31	61	56	88	81	.481	.574	.667	.759	.852	.944	1.037	1.130	1.222	1.315
8	7	35	32	62	57	89	82	.407	.500	.593	.685	.778	.870	.963	1.055	1.148	1.241
9	8	36	33	63	58	90	83	.333	.426	.519	.611	.704	.796	.889	.981	1.074	1.167
10	9	37	34	64	59	91	84	.259	.352	.444	537	.630	.722	.815	.907	1.000	1.093
11	10	38	35	65	60	92	85	.185	.278	.370	.463	.566	.648	.741	.833	.926	1.019
12	11	39	36	66	61	93	86	.111	.205	.296	.389	.481	.574	.667	.759	.852	.944
13	12	40	37	67	62	94	87	.037	.130	.222	.315	.407	.500	.592	.685	.778	.870
14	*12	41	*37	68	*62	95	*87	.963	1.055	1.148	1.241	1.333	1.426	1.518	1.611	1.703	1.796
15	*13	42	*38	69	*63	96	*88	.889	.981	1.074	1.167	1.259	1.352	1.444	1.537	1.630	1.722
16	*14	43	*39	70	*64	97	*89	.814	.907	1.000	1.093	1.185	1.278	1.370	1.463	1.556	1.648
17	*15	44	*40	71	*65	98	*90	.740	.833	.926	1.018	1.111	1.204	1.296	1.389	1.481	1.574
18	*16	45	*41	72	*66	99	*91	.667	.759	.852	.944	1.037	1.130	1.222	1.315	1.407	1.500
19	*17	46	*42	73	*67	100	*92	.592	.685	.778	.870	.963	1.056	1.148	1.241	1.333	1,426
20	*18	47	*43	74	*68	101	*93	.518	.611	.704	.796	.889	.981	1.074	1.167	1.259	1.352
21	19	48	44	75	69	102	94	.444	.537	.630	.722	.815	.907	1.000	1.093	1.185	1.278
22	20	49	45	76	70	103	95	.370	.463	.556	.648	.741	.833	.926	1.018	1.111	1.204
23	21	50	46	77	71	104	96	.296	.389	.481	.574	.667	.759	.852	.944	1.037	1.130
24	22	51	47	78	72	105	97	.222	.315	.407	.500	.593	.685	.778	.870	.963	1.056
25	23	52	48	79	73	106	98	.148	.241	.333	.426	.519	.611	.704	.786	.889	.981
26	24	53	49	80	74	107	99	.074	.167	.259	.352	.444	.537	.630	.722	.815	.907

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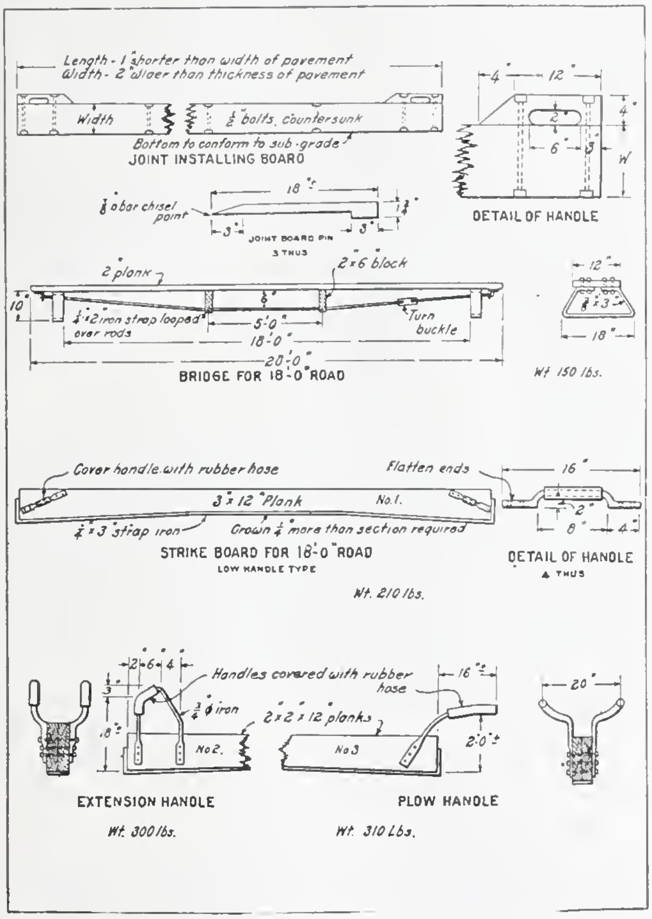
*When working to the nearest cubic yard use only left hand side of table, adding one yard to volumes marked (*).

Note.—For sum of E. A. larger than those given use table values, moving decimal point to right and add proportional part. Proportional Parts: 0—.000, .1—.093, .2—.185, .3—.278, .4—370, .5—.463, .6—.556, .7—.648, .8—.740, .9—.833. Example—Sum of E. A. = 73.8; volume = 67 + 1.333 = 68.333 cu. yd. Sum of E. A. = 738.8; volume = 683.333 + p. p. .740 = 684.07 cu. yd.

Suggestions for the Construction of Concrete Pavements

Useful suggestions on the inspection and construction of concrete roads, based on experiences with this kind of work in the southwest, have been prepared by Clyde E. Learned, Highway Engineer of the U. S. Bureau of Public Roads. The suggestions are printed in Public Roads, the official publication of the Bureau, from which the matter that follows is abstracted.

Concrete Mixing.—Hold the materials in the drum of the mixer for at least 1 minute. Do not use an excess of water in mixing, 30 to 35 gal. per cubic yard of 1-2-4 concrete is sufficient. When concrete has not been mixed enough and when too much water is used it will be noted that, as the batch comes out of the mixer, it lacks in uniformity.



Joint Installing Board, Bridge and Strike Board.

Concrete should stay in the mixer at least 1 minute. This is done so that the water will be thoroughly worked through the mass. If a mixer having a chute for distributing the mix is used, a fairly steep slope will be required. Otherwise there will be a tendency to use too much water to make the concrete flow. It is better to increase the pitch of the chute than to increase the amount of water in the concrete. If a bottom dump bucket of the boom type is used watch it to see that it does not leak too freely and allow the mortar to escape.

Placing Concrete.—Keep the strike board, joint installing board, roller, and finishing belt clean.

Break in the strike-board men to use care in screeding at the joints, having them make sure all excess concrete is removed, and that no low places are left at the joints. It may be necessary to try a number of men on the strike board in order to get those who are reliable and will take a little pride in their work.

A smooth riding surace depends more upon proper striking off than upon any other operation. The smoothness of a concrete pavement is very important, as imperfections increase the impact generated by the loads passing over it.

Work the concrete mixer uphill when feasible, as smoother results at the joints are thereby obtained.

Use a notched straightedge straddling the joints to determine if there are any raises or depressions on either side.

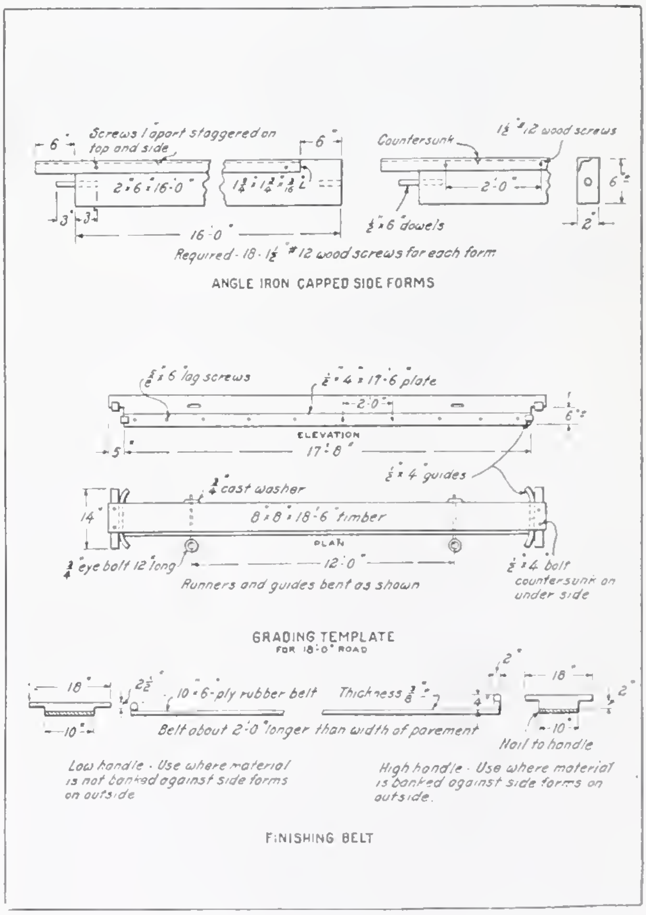
When a sidewalk edging tool is used at the expansion joint, make sure that it is not used until the concrete has taken a slight set; also that the work resulting from its use shows a good, clean rounded edge.

Have the asphalt joint strips kept flat before installing, as strips scattered all over the ground get kinks in them which are hard to remove and which may appear later in the concrete.

Installing Asphalt Strips. Use care in installing asphalt strips, as crooked points in a pavement are very unsightly.

The following method for installing asphalt strips produces very satisfactory results: A joint board is made of a 2-in. surfaced plank about 2 in. wider than the thickness, and 1 in. shorter than the width of the pavement, and is provided with handles at both ends. The board is held in place on the subgrade by two or three iron pins driven behind it, and the asphalt strips are placed flat against the board. A few shovels full of concrete are placed against the strips to hold them in place until the pavement has been advanced to that point. As soon as enough concrete is dumped in front of the joint board to fill the block, work is started on a new block by dumping concrete on the other side of the joint board.

The strike board having finished on the first block, and a part of the next block is ready for the strike board, the iron pins are removed and the joint board slowly withdrawn, leaving the asphalt strips in place in the pavement. In withdrawing the joint board have a man take hold of each of the handles and first tip the top of the board away from the strips. This results in freeing the strips and keeps them from adhering to the board. The joint board is then worked slowly up and down. This action results in pumping enough concrete against the strips to hold them in place. The joint board is then lifted clear of the concrete at one end and this end raised slowly till the whole of the board is freed. As the board is lifted one of the spreaders follows along behind the board, pushing concrete into the opening left by the board. When the joint board is removed entirely, the strike board is placed against the projecting part of the strip on the mixer side, enough concrete added in front of it to make up the deficiency caused by the removal of the joint board, and the striking off of the next slab begun.


Screws 1' apart staggered on top and side
6" 6"
2"x6"x16'-0"
1¾"x1¾"x³⁄₁₆" L
3" 3"
16'-0"
Countersunk
1½" #12 wood screws
2'-0"
½"x6" dowels
6" 2"
Required - 18 - 1½" #12 wood screws for each form
ANGLE IRON CAPPED SIDE FORMS
⅝"x6" lag screws
½"x4"x17'-6" plate
2'-0"
6"
ELEVATION
5" 17'-8"
½"x4" guides
¾" cast washer
14"
8"x8"x18'-6" timber
PLAN
¾" eye bolt 12" long
12'-0"
½"x4" bolt countersunk on under side
Runners and guides bent as shown
GRADING TEMPLATE
FOR 18'-0" ROAD
18" 2½" 10"-6-ply rubber belt Thickness ⅜" 2" 18" 2"
10" 10"
Belt about 2'-0" longer than width of pavement
Nail to handle
Low handle - Use where material is not banked against side forms on outside
High handle - Use where material is banked against side forms on outside.
FINISHING BELT

Side Forms, Grading Template and Finishing Belt.

In place of the wooden joint board, metal strips can be used, these having the advantage of leaving a smaller space behind the filler as they are withdrawn. However, this advantage is more than offset by the fact that they are constantly being bent by rough handling.

After the pavement is cleaned the joint filler should be cut to a uniform height by means of a square pointed shovel shod with two steel runners riveted to the under side of the blade, which is notched and provided with a sharp cutting edge.

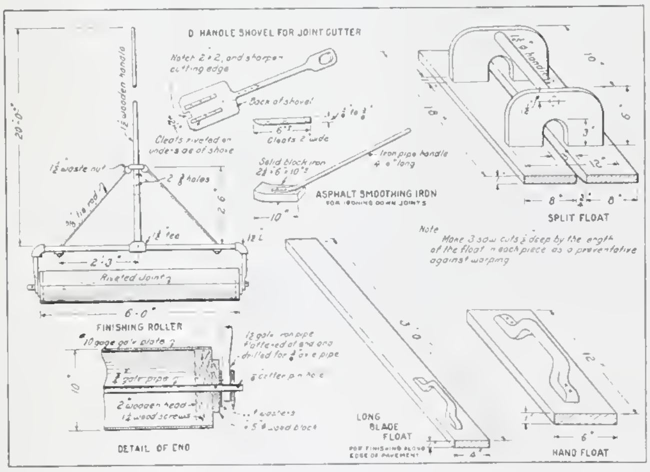
Joints.—Have the joints cut off high enough to provide for the extra volume needed to fill the space resulting from the use of edging tool. After the joints are cut, a heavy asphalt smoothing iron is heated and the joints are ironed out. By doing this the joints are sealed and protected by a mat of asphalt.

Split Float.—Use a large size split float on all joints, so that the pavement on both sides of the joint will be in the same plane. Many finishers get the impression that after a while they are experts and do not need a split float. However, under no circumstances should they be allowed to discontinue the use of this tool.

It is well to round off the edges of the pavement with a sidewalk edging tool.

Do not allow the finishers to use metal floats for finishing, as they produce too smooth a surface.

Testing Surface.—The finished surface should be tested with a 10-ft. straightedge laid parallel to the center line of the road, and there should not be a variation of over ¼ in. in the surface over this length, and where variations do occur they should be gradual.



Miscellaneous Tools Used in Concrete Pavement Construction.

Striking Off.—The strike board or screed is built from 3 to 4 in. wide and about 12 in. high. Its length should be about 2 ft. greater than the width of the pavement, and it should be shod on the finishing edge with an iron strap from ¼ to ½ in. in thickness. It should have a crown about ¼ of an inch greater than the crown of the pavement, to allow for deflections when it is used as a tamper. Substantial handles should be attached at each end.

The following method is used for striking off and tamping the pavement surface. Have the spreaders keep a small wave about 1 in. high in front of the strike board the first time over, making sure that no daylight appears between the concrete and the board. The first time over advance the strike board with a combined longitudinal and crosswise motion, this first passage leaving the surface a series of small transverse waves with a slight excess of concrete. Sometimes when too much concrete is deposited in front of the board it is necessary to first pull the concrete down to an approximate surface by means of the strike board, this being performed by a straight pull ahead on the board. On the second or return passage the board is used as a tamper to compact the surface, this being performed as follows:

One of the strike-board men holds his end of the board on the side form, while the other tamps the concrete by a succession of short, quick up and down strokes, at the same time advancing his end about 2 or 3 in. each stroke, the total advance being 3 or 4 ft. This operation is then repeated by the other strike-board man moving his end ahead, while the first man pivots his end on the side form. In this manner the entire surface is tamped, each man covering a series of fan-shaped sections. This tamping fills all pockets and pushes down all protruding stones. The strike board is then passed over the surface using the same motion of the strike board as in the first passage over the slab, and making sure that, during this passage, it rests on the side forms at all times.

It is sometimes necessary to pass the strike board over the surface four or five times in order to get the desired results, but ordinarily the three passages above described, are sufficient.

Rolling.—After striking off the pavement it should be rolled. This is done with a roller 10 to 12 in. in diameter, about 6 ft. long, and weighing about 1 lb. for each inch in length. The roller is provided with a long handle which enables the operator to reach across the pavement. In rolling, roller is advanced about 2 ft. for each complete passage. The effect is that of a rolling squeegee. It consolidates the top layer and removes practically all the surplus water, besides removing any transverse waves, thereby improving the riding qualities of the road. Do not use the roller too soon after striking off the pavement, as it tends to flatten the crown. The proper time varies from ½ hour to 2 hours, after the concrete is placed. The roller facilitates the use of the finishing belt, especially where crushed stone is used, as it pushes down the sharp projecting edges and corners. It is possible to use the roller much quicker where crushed stone is used than where gravel is used.

The roller often causes longitudinal waves adjacent to the side forms at the end of each crossing. These should be eliminated with a hand float before the application of the finishing belt.

Belt Finishing.—For finishing the pavement a 10 or 12-in. canvas or rubber belt is used. This should be about ⅜ in. thick, at least 2 ft. longer than the pavement is wide, and have wooden handles bolted to each end. The following method produces very satisfactory results. The pavement is first gone over with the belt, using a sweeping stroke about 18 in. in length with longitudinal advance at each stroke of from 4 to 6 in. On the return trip a shorter, quick stroke about 8 in. in length is used, the advance being from 6 to 8 in. for each stroke. The third and final passage of the belt is performed by holding the belt down close to the side forms and advancing it rapidly over the surface with as little side movement as possible. After the belt finishing the pavement should present a smooth, uniform surface.

Curing.—In curing concrete two methods are in general use:

First, by covering the pavement with a layer of dirt from the shoulder materials, and keeping this wet down.

Second, by checking off the pavement by means of small earth dams and covering checks with small ponds of water.

The second method of curing is more positive, and should be used when sufficient water can be obtained. It has its disadvantages when used on grades and banked curves but usually these can be overcome by building smaller size checks. The first method, i. e., covering with dirt, may be cheaper in most cases, but when clay or other adhesive material is used for covering, trouble is apt to be experienced in its removal, especially if traffic gets onto the pavement while the covering is still in place. Furthermore, most contractors wish to remove an earth cover with blade machines, by which method the asphalt strips at the joints are likely to be damaged.

Curing by ponding shows up the irregularities in the surface and in the setting of the side forms, which, while of no value in correcting completed work, helps to determine what improvements should be made on work still to be done.

Canvas covers should be provided for at least a third of a maximum day's run in order to eliminate sun and wind checks; also as a provision against rain-washed surfaces. If a surface does become washed by rain, sprinkle it over with neat cement and pass the finishing belt over it two or three times.

When the average temperature is below 50° it is better to omit covering and ponding, and sprinkle the surface with water whenever it appears to be drying out.

Side Forms.—Look over the side forms every few days and note whether there are any with warps or deflections which should cause them to be thrown out. If there are, be sure to disfigure them enough so that they will not appear in the next day's run.

See that the contractor uses care in setting the side forms and that they are held firmly to line and grade. Tamping with the strike board often results in settling them. Check the forms with a level every once in a while, as it has a very beneficial effect on the work of the form setter to know that his work is being checked.

Do not let the form setters use stones to hold the forms up to grade, but have the contractor provide them with blocks. A still more satisfactory method for setting forms is to drive stakes about every 8 ft. and set the forms on them.

Cement Sacks.—Count the cement sacks at the end of each block. This keeps every one informed as to the cement content of the pavement.

Have the contractor remove all cement sacks every night. If sacks are left on the work they are apt to be mixed with those from the next day's run.

In piling cement ahead of the mixer, have boards placed under any that will remain out over night.

Rations for Arizona Convict Labor Camp

The following table shows the amount of food allotted to each convict per month at the Clifton camp of the State of Arizona:

	Lb.		Lb.
Flour, wheat	12	Fresh beef, pork or mutton	23.5
Flour, milo maize	1.6	Flour, barley	2
Rolled oats	1.7	Corn meal	22
Sugar	3	Macaroni	.8
Prunes	1.5	Vermicelli	2
Canned peas	2.4	Dried apples	2.0
Dried peaches	.1	Dried apricots	4.0
Canned tomatoes	4.4	Canned corn	6
Cottolene	4	Bacon	5.2
Beans	1.6	Ham	1.6
Onions	3.7	Lard	1.5
Velva sirup	5.0	Condensed milk	3.9
Coffee	2.6	Potatoes	17.6
Rice	1.7	Eggs	17
Cheese	1.0		

A force varying from 90 to 100 men from the state prison is worked at this camp.

For breakfast the men are served corn, bacon, mush, sirup, bread and coffee. Twice a week hot cakes are added.

For dinner there are potatoes, beef stew, beans, bread, dried fruits, and coffee.

Supper consists of either steak or stewed beef, potatoes, rice, macaroni, canned sweet corn, peas, or tomatoes alternatively, bread and coffee.

For Sunday breakfast they get ham and eggs. Twice each week either pie or cake is served with the dinner, and three times each week they are furnished with smoking or chewing tobacco.

Complaint about the food is seldom heard and the men are found to be gaining in physical condition from the time they reach the work until they leave it.

Status of State Highway Work in Nebraska.—The Nebraska State Highway Department, according to its June report, has been handicapped during the present year by a shortage of engineers, for making preliminary surveys. This condition has been caused by the great number of engineers who are still in the army service, and partly by the universal demand caused by the necessary expansion in the Department necessitated by recent road legislation. It is expected this condition will be relieved by men returning from the army, whose discharge has been asked for, and their early return promised by the War Department. As soon as these men are returned surveys will be made in every county in the state, preparatory to letting contracts. In several counties through which the Lincoln Highway passes, work has been delayed by the "right of way question," the desirable road being on land claimed by and leased from the railroad company, and in view of the fact that Federal money cannot be spent on leased right of way, the preparatory work of construction is being held up until the right of way can be secured. At the present time there are 15 parties out on preliminary survey work and it is the hope and expectation of the department to have 25 more parties in the field by the first of July. Contrary to early expectation there have been enough contractors bidding on work to take it as it has been advertised, this with the exception of the concrete paving work, bids for which have been asked in two counties where the counties or communities have provided a part of the funds. Contracts that have been awarded are being carried out in an expeditious manner, in spite of adverse weather conditions. While the bids on Federal state work have been very high as compared with pre-war prices, yet, they are somewhat lower than those received in many other states as shown by reports from highway departments.

Cost of Motor Truck Operation for Refuse Collection

In connection with a study of refuse collection at Rochester, N. Y., the Rochester Bureau of Municipal Research, Inc., of which James W. Routh is Director, collected a considerable amount of data on the use of motor trucks in municipal service. These data are given in a report issued recently by the Bureau, from which the matter following is abstracted.

In 1914 a 5-ton truck equipped with a specially designed 10-yd. collection body was given a trial in house to house collection of garbage and ashes on a 3-mile haul in the Borough of the Bronx, New York City. It was given a further trial in hauling garbage from relay stations in the outlying sections of the Borough. On the 3-mile haul in making house-to-house collections the truck did not prove as economical as the 1-horse carts generally used. But in hauling from relay stations on the longer haul the truck showed a considerable saving over horse-drawn carts. The haul for this work was approximately 7 miles. The truck made four round trips for a total of 54.2 miles and hauled 27.6 tons of garbage as against about 1½ trips made in the same length of time by a 1-horse cart hauling approximately 1½ tons (9/10 tons per load). On the shorter haul the cart made three round trips per day for a total distance of 18 miles, including house-to-house collections and hauled 5.4 tons; the truck made five round trips for a total distance of 32.7 miles and hauled 23.85 tons.

The poorer showing of the truck on house-to-house collections was attributed to the time spent in loading. Although four helpers were provided the time so spent represented more than one-half the total time. The time spent in traveling to and from the dump was only one-fifth the total time. On relay work, however, the loading time was only 35 per cent of the total time.

The 1-horse cart outfit cost $4.32 per day. The total daily cost of operating the truck was $13.70, distributed as follows:

Item.	Total cost.	Per cent of total.
Gasoline	$2.41	17.6
Oil	.75	5.4
Truck depreciation (cost $5,000, life 5 years)	2.78	20.3
Interest on investment at 6 per cent	.83	6.1
Repairs, labor, materials, tires, grease and miscellaneous	4.07	29.7
Garaging	.30	2.2
Driver's pay	2.56	18.7
Total	$13.70	100.0

The New York Department of Street Cleaning has used large tractor-trailer motor propelled collection units to some extent. These are giant outfits hauling 25 cu. yd. of refuse per load. Collections of ashes, rubbish and garbage are made simultaneously, but in separate compartments. The average haul is about 1½ miles. Special equipment is provided for unloading the refuse onto scows. The principal factor tending to produce economy from the collection standpoint is the fact that all refuse is dumped at a common point of disposal. For this reason all refuse may be collected at one time by providing separate refuse compartments on the collection vehicles.

In Philadelphia a part of the collection equipment has been motorized. Five-ton trucks equipped with 12-yd. bodies have proven economical in the collection of ashes and rubbish from sections where the haul to the dump averages 6 miles.

In a report by the Efficiency Division of the Chicago Civil Service Commission made public in July, 1915, it is stated that after a thorough study of the question of motorizing Chicago's collection equipment the continued use of horses in garbage collection was found to be justified. The report states that the data assembled for gas and electric trucks warrant their adoption only for hauling after horse-drawn carts have made the house-to-house collection. These figures are based on a $5.50 daily wage per team. If the cost of teaming were increased to $6 per day, it is stated that there would be a slight saving by using motor equipment, but this would not be sufficient to warrant the change at least for some time to come. The report states that the haul in Chicago varies from 1½ to 5 miles. As between the gasoline and electric trucks, the latter were found to be the more economical. The haul below which a 3-ton electric truck would not be economical when measured against a $5.50 team was found to be 1.8 miles. Against a $6 team it was 0.8 mile.

Three-ton gasoline trucks were found to be not as economical as either a $5.50 or $6 team.

The fixed and mileage charges for gasoline and electric trucks were as follows:

Item.	Total cost— Gasoline.	Total cost— Electric.
First cost of 3-ton truck or tractor	$4,000.00	$4,000
Fixed charges:		
Fixed charges on investment per year at 4 per cent	160.00	160.00
Garage	300.00	300.00
Insurance (fire and liability)	190.00	183.00
State license	4.00	4.00
Driver	960.00	960.00
Obsolescence, 5 per cent	200.00	200.00
Contingencies (interest on operating stores, general superintendence, etc.), 2 per cent	800.00	80.00
Total fixed charges per year	$1,894.00	$1,887.00
Total fixed charges per day (1/300 year)	6.31	6.29
Variable expenses per mile:		
Depreciation	$0.0573	$0.0340
Tires	.0600	.0600
Maintenance and repairs	.0300	.0300
Lubrication (oil and grease)	.0050	.0050
Energy (gasoline 13½ ct. per gal., electricity ½ ct. per kw. hour)	.0344	.0050
Total variable expense per mile	$0.1767	$0.1340

The cost for hauling with horses was given as follows:

Item.	Teams costing— $5.50 per day.	Teams costing— $6.00 per day.
Fixed charges for equipment	$0.021	$0.021
Horses and driver	5.500	6.000
Wagon depreciation, life 22,000 miles	0.084	0.084
Maintenance and repairs at 5 per cent	0.021	0.021
Total daily expense	$5.626	$6.126

In Los Angeles motor trucks are used in the collection of all non-combustible refuse. Two 2½-ton trucks are used to haul garbage from the outlying districts where the haul averages 8 miles or more. One driver and two helpers compose the crew and two loads are collected daily. For the remainder of the city on the shorter hauls teams are still used. The cost of garbage collection with motor trucks on the long hauls is given as $2.76 per ton. On the shorter hauls the cost is $2 per ton using teams.

A certain firm in Rochester employing both horses and motor trucks in lumber and building material deliveries states that the economical low limit of haul for motor trucks is found to be 2¼ miles.

The average cost of truck operation by this firm for the last three years has been $11.20 to $12.30 per day. (This includes the cost of two 3-ton and two 2-ton trucks.) Items included are fuel, lubricants, tires, repairs, license fee, liability insurance, garaging, drivers' wages and depreciation. Drivers were paid $17 to $19 per week. Twenty per cent was allowed for depreciation.

Mr. C. V. Montgomery, who has charge of a large fleet of motor trucks on paving work in Philadelphia, in a statement appearing in the Engineering News of Jan. 11, 1917, places the cost of operating a 5-ton truck 50 miles per day at $17.91. Fixed charges amount to $5.39 per day or 30 per cent of the total. This cost evidently applies to 1916 conditions. The distribution is as follows:

Fixed charges.	Per day.	Per cent of total cost per day.
Depreciation* ($4,100 first cost—$400 scrap value/1,200 days)	$0.46	2.6
Insurance (liability, fire, collision)	.58	3.2
License fee	.10	.6
Truck foreman (supervising 3 trucks)	1.25	7.0
Driver	3.00	16.7
Total fixed charges	$5.39	30.1

Variable charges.	Per mile.	Per day at 50-truck-miles.	Per cent total cost per day.
Depreciation* ($4,100 first cost—$400 scrap value/15,000 miles)	$0.0629	$3.14	17.6
Gasoline at 25 ct. (3 miles per gal.)	.0833	4.17	23.3
Lubricating oil (64 miles per gal.)	.0055	.27	1.5
Tires	.0386	1.94	10.8
Repairs	.0600	3.00	16.7
Total variable charges	$0.2503	$12.52	69.9
Fixed charges (at 50 miles per day)	.1078	5.39	....
Total cost per mile	$0.3581	.....	....
Total cost per day	.....	$17.91	100.0

*About 15 per cent of first cost depreciates with passage of time, while about 85 per cent is proportional directly to mileage run.

The cost of operating a 5-ton truck used in the delivery of sand and gravel on the Pacific Coast during a 5-months' period in 1917 was approximately $13.40 per day. This includes all charges. Capacity loads were hauled an average distance of 6.1 miles over roads of various kinds, equally divided between gravel and dirt, with many hills, some of them steep. The average distance traveled daily was about 60 miles. The costs were distributed as follows:

Item.	Total cost.	Per cent of total.
Fuel	$ 303.25	18.1
Oil and grease	69.79	4.2
Tires	154.93	9.3
Repairs and parts	21.06	1.3
Wages	508.75	30.4
Interest at [illegible] per cent	218.78	13.1
Depreciation at 20 per cent	394.66	23.6
Total	$1,671.22	100.0

The cost of hauling paving materials in Detroit with a 5-ton truck during 1917 was $14.85 per day, including all costs. The truck hauled an aggregate of 35 tons in seven trips, the average haul being 4½ miles.

The cost of operating a 3½-ton truck under average service conditions on the roads of Southern California over a considerable period of time was found to be $9 per day. This includes all cost of upkeep, supplies, depreciation, wages of drivers, etc. The first cost of the truck was placed at $3,500 and its life at 10 years, assuming that the truck traveled 25 miles per day. Gasoline was purchased at 16 ct. per gallon and the driver's salary was $960 per year. Roads were good and operating conditions generally very favorable. Itemized costs (for the estimated life of 10 years) follow:

Item.	Total cost.	Cost per day.	Per cent of total.
Insurance	$1,350	$0.45	5.0
License and taxes	380	.13	1.4
Interest at 6 per cent	2,100	.70	7.8
Depreciation	3,500	1.17	12.9
Administration	415	.14	1.5
Storage	960	.32	3.5
Gasoline at 16 ct. per gallon	2,400	.80	8.9
Oil, grease, waste	750	.25	2.8
Tires (less first cost)	2,345	.78	8.7
Driver's salary	9,600	3.20	35.5
Maintenance	3,250	1.08	12.0
Total for life of truck	$27,050	$9.02	100.0

The first cost of a truck with a collection body would be somewhat higher than is here given. As a matter of fact, the city of Rochester awarded a contract to the Selden Motor Vehicle Co. in December, 1917, for two 3½-ton trucks each equipped with a special 6-yd. collection body at $5,031 each. Other costs also have increased proportionately since the above estimate was made. It is believed, however, that a competent driver could be employed at less than $960. It should be possible to employ a truck driver at $900 annually if he were given permanent employment. Also interest rates on the investment should not amount to more than 5 per cent. The life of a truck used in house-to-house collection work would probably not be as long as in other work, due to frequent starting, stopping and generally hard usage. A life of 5 years with a daily average mileage of 25 miles would seem to be a fair estimate for the useful service derived from the truck. At the end of that time the estimated scrap value would be $500. With these data the following estimate is made of the daily cost of operating a truck in ash collection:

ESTIMATED DAILY COST OF OPERATION OF A 3½-TON MOTOR TRUCK IN REFUSE COLLECTION.

Fixed charges:	Total daily cost.	Per cent of total.
Depreciation: First cost, $5,031.35, life 5 years, scrap value $500	$0.45	3.5
Insurance (liability $120, fire $45 per year)	.55	4.3
Storage	.30	2.4
Driver ($900 per year)	3.00	23.6
Interest (5 per cent annually)	.84	6.6
Overhead supervision (same organization as for city stables)	.40	3.2
Total fixed charges	$5.54	43.6

Variable charges:	Per mile.	Per day at 25 miles.	Per cent of total.
Depreciation: First cost $5,031.35, life 5 years, scrap value $500	$0.1027	$2.57	20.2
Gasoline at 22 ct. gal: (3 miles per gallon)	.0733	1.83	14.4
Lubricants (oil, grease, waste)	.0100	.25	2.0
Tires	.0500	1.25	9.9
Repairs and sundries	.0500	1.25	9.9
Total variable charges	$0.2860	$7.15	56.4
Total fixed charges at 25 mile per day	.2216	5.54	43.6
Total daily cost of operation	$0.5076	$12.69	100.0

It is assumed that a certain small amount of depreciation is due directly to the passage of time. In the estimate, therefore, 15 per cent of the total depreciation is included as a fixed charge and distributed over 1,500 days, the estimated useful life of the truck. The remaining 85 per cent depreciation is assumed as being directly proportional to the mileage run. Operated 25 miles per day with a life of 1,500 days' service, the total distance that the truck would travel would be 37,500 miles. The estimated depreciation for the life of the truck on this basis is 23.7 per cent of the total daily cost of operation. This is rather a big allowance for depreciation, but when the nature of the work is considered it is not high in comparison to depreciation of trucks used in straight commercial hauling work. A truck used in house-to-house collection work must be started and stopped many times in the course of each loading. The motor must be kept in constant motion because each stop is of short duration. On account of the many starts and stops also the truck must of necessity cover a considerable distance each day at a speed much slower than its economical speed of operation. Combined with all of these factors the truck must be operated continuously in the presence of grit and cinders from ashes and dust from street dirt. For these reasons not only is depreciation sure to be high, but the unit cost of fuel, lubrication, tires and repairs is also bound to be more than similar costs under normal commercial operating conditions.

Asphalt Association Formed

The Asphalt Association has been organized by representatives of several asphalt producing companies, for the purpose of disseminating information on the uses of asphalt particularly in road and street paving and co-operating with public officials and scientific bodies and colleges in bringing about the most effective use of this material. The headquarters are at 15 Maiden Lane, New York City. Other offices will be established soon in Chicago, Atlanta and in other cities. The Association has elected the following officers: President, J. R. Draney, general sales manager U. S. Asphalt Refining Co.; vice president, W. W. MacFarland, assistant secretary Warner-Quinlan Co.; treasurer, N. G. Luykx of the Freeport & Mexican Fuel Oil Corp.; secretary, J. E. Pennybacker, formerly of U. S. Bureau of Public Roads, during the war Secretary of the U. S. Highways Council and more recently director of roads of the American Automobile Association. Mr. Pennybacker will be the active officer in charge of the affairs of the association. There will be a Research and Technical Department of the association which will be managed by Prevost Hubbard, Chief of the Research and Testing Division of the United States Bureau of Public Roads prior to his affiliation with the association. Field engineers who will devote their attention to aiding state, county and municipal authorities in the working out of their highways problems, include Fred W. Sarr who was Deputy State Highway Commissioner of New York in charge of the maintenance, repair and reconstruction of all state and county highways comprised in New York's great system. A. T. Rhodes for years street commissioner of Worcester, Mass. and later secretary of the Granite Paving Block Manufacturers Association and, who is vice president of the Massachusetts Highway Association, will look after the New England territory and other eastern points.

At the Chicago office of the association, J. B. Hittell, formerly chief engineer, Board Local Improvements of Chicago, and president of the Illinois Society of Engineers, will be in charge of the work of the association in the middle western states.

Equipment Owned by Connecticut State Highway Department.—On Sept. 30, 1918, the State Highway Department of Connecticut owned road building equipment valued at $98,475. The inventory of this equipment, according to the last annual report of Charles J. Bennett, State Highway Commissioner, was as follows:

Automobiles, 28	$16,200
Trucks, 64	69,025
Rollers, 4	6,000
Crushers, 3	2,000
Loaders, 2	1,000
Compressors, 3	3,000
Steam boiler, hoisting engine and concrete mixer.	650

Tree Planting Along State Trunk Highways in Michigan.—A recent act of the Michigan Legislature places tree planting along state trunk highways and other roads built under the state reward system in charge of the State Highway Commission and the State Board of Agriculture. Under the law it is their duty to set out ornamental, nut-bearing or other food-producing trees, suitable for shade trees. The Michigan Agriculture College and Public Domain Commission are authorized to distribute stock for the same purpose at nominal cost to local officials and private individuals who will set it out at intervals of 20 to 40 ft. along the roads. Injuring trees along the highways or affixing notices of any kind to them is made a misdemeanor punishable by a fine of $1 to $25 or imprisonment for not more than 30 days.

Mountain Highway Reconnaissance

The selection of highway routes in a mountainous region requires the exercise of certain well-developed faculties almost as rare as what is sometimes called "horse sense," writes T. A. Bedford, Division Engineer, California State Highway Department, in Public Roads. The reconnaissance engineer must have a keen sense of proportion, course, distance, and locality; something almost akin to animal instinct. If he does not possess this, he would better specialize on something else.

Any competent engineer may, by mechanical means, take accurate topography over all possible routes between two points and by trial lines, shifting and calculating, find, in the course of time, the most economical location for a highway and yet, in the end, get it in the wrong place and have no money left with which to build.

As for methods, the first things to be determined are the points which are to be connected up by the road; next, a thorough knowledge of the topography of the intervening country should be obtained by walking out the ridges and climbing the highest peaks to get a general idea of topography and then following out the canyons or main water courses to get a more accurate knowledge of the topography, as the road will most likely follow the watercourses. A simian ability to climb trees is a useful accomplishment for the engineer at this stage of the reconnaissance.

Thus with a mental picture of thousands of square miles of topography standing out before the mind, like a huge relief map, roads must be "looked into" place and the likely routes selected for further examination. The controlling points and influence points on the routes should be picked out next. A probable selection must be made of the lines connecting these points and afterwards it is necessary to determine if a grade line run from one to the other will fall below the maximum grade adopted. These grade lines should be developed by well-trained assistants, who may work singly in open country but who must work in pairs in dense undergrowth. With clinometers and flags, trial grade lines are run between controlling points and bits of colored cloth tied on the branches as markers.

After the final route is selected, it is gone over carefuly and strips of white cloth are tied on branches of trees to guide the chief of survey party, who runs a preliminary line from flag to flag. If the reconnaissance work is well done, the final location will fall within the cross-sections taken from the preliminery line.

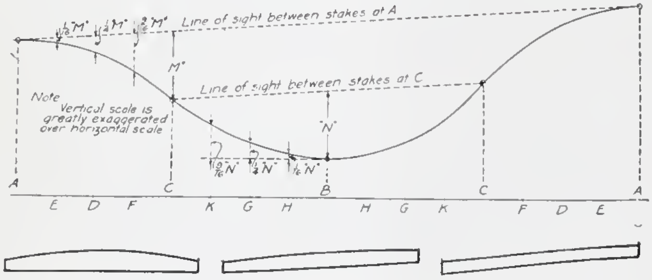
In a large percentage of mountain-road problems, snow conditions materially influence the location of the road. A road located with a southern exposure and exposed to the sun's rays and the warm south winds will be clear of snow much longer than one with a northern exposure. Furthermore, since the snow lies longer on the northern slope and the sun does not reach it to dry it out, the vegetation is heavier, the soil much deeper and the roadbed harder to drain and slower to dry out.

There are a thousand and one other conditions which may affect the road location. In one instance, a mammoth hydraulic placer mine made a certain location possible for one of the California state highways, while a similar mine in another part of the state made the desired location for another road impossible.

A hillside location may be preferable to a location through an adobe flat carrying an excess of irrigation water. A high mountain ridge route, open and cool, with plenty of desirable camp sites, though closed a portion of the year by snow, may be preferable to a deep canyon route open the year round, if the principal traffic is to consist of summer tourists and the canyon be narrow and hot, with few places to turn off the road. But if the principal traffic is to be freight, which will be continuous through the winter, then the canyon route is to be preferred. Such considerations, however, may lead the engineers into prophecy. Who can say what the future may bring or what class of traffic should be favored?

Method of Staking Out Concrete Fords or Dips

In recognition of the many desirable features of the concrete ford or "dip," the State Highway Department of Texas has adopted a standard of design and in many cases permits the use of this drainage structure on its state highways. A highway should be improved, where the available funds permit, so that the service it will render may be uninterrupted. The flow of water across a paved road surface is an obstruction to traffic and should be avoided where possible; therefore, a concrete ford or dip should be used only when economic reasons compel, due to the great additional cost of the bridge necessary to take its place. Where concrete dips are used they should be designed so as to provide required drainage facilities with least possible obstruction to traffic, either by reason of abruptness of change in gradient of the roadway or by reason of depth of water on the submerged portion of the pavement and the frequency of this occurrence. The concrete dip and the overflow concrete road with its approaches are, however, in the nature of makeshifts, used because available funds are inadequate to build the necessary culverts, approaches and trestles that would be required in the same locality to provide a dry roadway. The low-water bridge falls in the same class. An interesting description of the design features and methods of staking out these concrete dips is given in the June Concrete Highway Magazine by Mr. George A. Duren, formerly State Highway Engineer of Texas.


$\frac{1}{16}$M"
$\frac{1}{4}$M"
$\frac{9}{16}$M"
Line of sight between stakes at A
M"
Line of sight between stakes at C
Note
Vertical scale is greatly exaggerated over horizontal scale
"N"
$\frac{9}{16}$N"
$\frac{1}{4}$N"
$\frac{1}{16}$N"
A
C
B
C
A
E
D
F
K
G
H
H
G
K
F
D
E

Section at A

Section at C

Section at B

Sketch Showing Positions of Staked Sections to Outline Profile of Concrete Paved Dip.

In order to insure the safety of the public and to secure a roadway of pleasing appearance, care and good judgment must be applied in the design and installation of these structures. The concrete dip must so provide for drainage that the depth of water and its velocity across the roadway will not present an extreme hazard to the life and property of persons using the highway. Where the depth and velocity of water occasionally assume dangerous proportions, suitable warning signs should be provided.

The structure should be built so that it will neither be damaged nor undermined by the erosion of overflowing water. As the lowest point of the dip should allow for the ready passage of water and drainage of the upstream side of the water course, the transverse surface of the road at this point should be a straight line with the downstream edge from 1 to 3 in. lower than the upstream edge. The ends of the concrete approaches of the dip should extend to a point above the flow line to prevent erosion of abutting road surfacing; and to provide easy traveling, it should be extended to complete the vertical curve at the ends of the approach. Unless this is done, it is practically impossible to maintain the necessary cross section and profile of vertical curves to provide easy riding. Approaches should be reverse parabolic curves in order to reduce to a minimum shock to the springs of a rapidly moving vehicle.

This curve is somewhat difficult to stake out properly in such a way as to warp correctly the cross section from the crowned surface at the apex to the straight surface at the bottom of the dip. The process is more difficult to describe than to perform, but where opposite ends of approaches are approximately at the same elevation, and the approaches of approximately the same length, the following description should make the procedure intelligible:

First, set a line of stakes across the roadway at the points A shown on the accompanying diagram; these being at the apexes or ends of the approaches. The top of these stakes should be driven flush with the desired crowned surface of the pavement, one stake being set on the center line and one each at the outer edges of the pavement, and other stakes at the half and quarter points each side of the center line.

Set the same number of stakes at the point B, this being the lowest point of the dip, with the tops of these stakes flush with grade and profile of the flow line. It will be remembered that at this point the surface of the pavement is to be a straight line with the downstream edge slightly lower than the upstream edge.

At the points C half way between A and B set corresponding stakes with the top driven midway between elevations of corresponding stakes at the top and bottom of the approaches. This can be done with the aid of three equal length tee-boards, two of which establish a parallel line of sight to the tops of the corresponding stakes at A and B while the third tee-board is used to "sight in" the tops of corresponding stakes for the mid-section at C. The resulting stakes at the points C will have their tops conforming to a section having half as much crown as is given to the sections at A. Then sighting over equal length tee-boards held on corresponding stakes at the points A mark the line of sight on a board held vertically on the corresponding stake of the section at C. Note the difference in length between that of the tee-boards and the intercept on the board held at C from its lower end to the mark. This will be the difference in elevation between the stakes at C and the line between the points A. Then set rows of stakes at the points E, D and F, these being the half and quarter points on the upper halves of each approach. The top of the stakes at sections E, D and F should be respectively, 1/16, ¼ and 9/16 of the difference in elevation between corresponding stakes at A and C, measured down from the line of sight established between the points A. This will establish points for the pavement surface at the correct grade and warped surface for the upper halves of the approaches.

Next, set the stakes for the lower halves of the approaches by establishing a line of sight parallel to the tops of corresponding stakes at the points C by means of the equal length tee-boards, holding board on the stakes at the point B and mark the line of sight between the points C. Measure the difference between the intercepted length on this board between the line of sight mark and the lower end, subtracting from this distance the length of the tee-board used at the points C. Divide this difference by 16 and by sighting from the tops of corresponding stakes in the cross sections at C, set the tops of stakes in the section H, G and I respectively, 1/16, ¼ and 9/16, above the top of the stake at B. This will complete the stakes required to give the proper surface elevation for the lower halves of the approaches.

From this description, the engineer will be able to stake out properly almost any combination of approaches regardless of the fact that the apexes of opposite approaches may not be at the same elevation.

In the above discussion, procedure has been outlined for setting 72 stakes in each half of the approach and the stakes for the bottom cross section at B. If the paved way is narrow, the cross section of the roadway may be indicated by fewer stakes. However, to secure properly the parabolic form of curve of both approaches, 9 stakes should be placed parallel to the center line of roadway for each stake necessary to outline the cross section of the apexes. In general, the approaches should be of equal length, but this is not necessary if it is desirable to confrom more nearly with the ground, in which case the length of these approaches may be different; but the above rule should be used in order to secure a compound parabola which more nearly fits the law of moving and falling bodies than any other curve.

In fixing the length of approach and the amount of vertical drop in this distance, consideration must be paid to the speed of traffic. In no case should the vertical drop be greater than the curve representing the trajectory of an object moving at this rate of speed, since such conditions would very likely cause the wreck of any vehicle moving at the same velocity.

Transitions between higher and lower levels secured in this manner furnish the easiest possible riding consistent with rate of change in direction and elevation of travel, and at the same time furnish a most natural and pleasing transition of the warped surface of the roadway from one cross section to another.

Methods of Maintaining Winter Roads in Quebec*

By A. LALONDE,
Assistant Engineer, Outremont, Que.

In the maintenance of winter roads, we have to take into account two kinds of traffic: (1) Sleigh traffic; (2) mixed traffic, chiefly automobiles.

As regards sleigh traffic we need not linger at any length; there is no snow to be removed except where it accumulates in large drifts. The system of spreading the snow on the streets or on the roads, to be rolled and hardened with a snow roller, does not always give satisfaction as regards the second class of traffic. It is plain that this method of caring for the roads should only be used at the beginning of the season to prepare the foundations at the time of the early frost, and later to prevent the formation of ruts.

Where the traffic is confined exclusively to sleighs, I do not know of any machine more useful than the snow roller. The rolling process produces a surface hard enough to support loads of considerable weight. The snow which gathers on the side thus disappears and the road is kept free from snow, which decreases the cost of maintenance. We can thus have fairly good roads over 6 or 7 ft. of snow; everything depends upon the ability of the man in charge of the roller, and the help given him by a few men to level the surface where there is need to do so.

It is in the case of automobile traffic that difficulties are added and the problem becomes very difficult and costly to solve. First of all there must not be more than 6 in. of snow covering the roadbed. The organization system to deal with the snow must be restricted. A foreman, for instance, should be free to employ all the men he requires in urgent cases; the number of hours of labor should not be limited. The different gangs should begin their work as soon as the snow begins to fall and keep up with the storm, if possible, in order to prevent too large an accumulation of snow. Otherwise, if the storm is given headway, if too much snow is permitted to accumulate, the cost of removal will be greater, the snow having become more compact. Automobile traffic will be interrupted for some time, and it would be impossible to use motor trucks with a snow plow, which would not be able to work when the surface of the road is covered with 6 or 7 in. of fresh snow.

When a storm breaks during the night, the gang should be put to work early in order that traffic may not be obstructed in the morning. The space of road cleared should be wide enough to permit two vehicles to pass. The road should be carefully watched before and after the frosts set in. A little neglect during these periods, which are ordinarily short, can undo a month's good work.

Snow fences should be used wherever they are found necessary. They are very effective when they are properly placed. Their cost is relatively low, and they can be used for a number of years if care is exercised in moving them and they are properly piled after the winter to prevent as much as possible the deterioration of the wood.

I shall now touch briefly upon snow removal at Outremont. That city has a superficial area of 975 acres. It is divided into 13 sections, with a man in charge of each section. These section men, with the help they require, look after the sidewalks, the crossings and catch-basins. Twenty-eight snow plows are used. We also use four scarifiers, two single and two double, fitted up with steel teeth, which make small ridges on the slippery surface of the sidewalks. The plow may also occasionally be used as a scarifier by the addition of a small steel bar with teeth. The catch-basins are thawed by means of a steam boiler. Twenty-eight miles of sidewalk (5 ft. wide on an average) were cleared, maintained and sprinkled with sand last winter at a cost of $373.15 per mile; 24 miles of drains were opened at a cost of $130.15 per mile. These figures include (pro rata) the cost of keeping the catch-basins open.

Special gangs were employed for the clearing and maintenance of the streets; 16 miles of streets were cleared and opened to automobile traffic throughout the winter at a cost of $165.81 per mile. The snow is not carted from these streets. Throughout the winter 2.3 miles of street with double tramway tracks were cleared and kept open for automobile traffic at a cost of $1,535.20 per mile. This amount, so much higher than for the streets mentioned before, is explained by the fact that traffic is considerably heavier on account of their greater width (15 to 58 ft.) and also because the snow is completely removed and carted to vacant lots or to the city snow dump.

For the removal of snow, vehicles with a capacity of 8 cu. yd. are employed. Half the cost is paid by the tramway company. We are assisted on these streets by the tramway company, whose snow plows and levelers accomplish good work. The city's equipment to clear its streets is as follows:

Six steel snow plows, 20th century type.

One road plow, mounted on runners. (This is very useful and can also be used in summer.)

One double, wooden plow drawn by six or eight horses. This plow is 24 ft. wide, with wings on either side to level the sides of the road. It is used particularly after a snow fall to widen the road, and also during the month of March to level the surface.

Two snow plows 8 ft. long (two sections of 4 ft.), 6 ft. in diameter, and drawn by two horses. These are used at the beginning of the winter and after storms, when the surplus snow has been removed.

One 5-ton motor truck, with plow of the "good roads" type fitted in front. This truck is very useful, but only where the bottom of the road has been hardened.

One rotary snow plow of the "Stadig" type, invented by W. L. Stadig and manufactured by the Canadian Fairbanks-Morse Co. It resembles very much the plows used by railway companies. It is a steel structure, measuring 20 ft. in length and weighing about three tons.

This rotary plow can hurl the snow a distance of 40 ft., and a peculiar fact notable in this operation is that the snow is powdered so fine and scattered so evenly that it seems to have disappeared.

Drifts of 5 or 6 ft. may be cleared with this machine. It is equipped with an apparatus to load the snow into vehicles at the side of the road. A vehicle with a capacity of 8 cu. yd. can be loaded in 3 minutes. We made a comparison last winter of the weight of snow loaded with this machine and the weight of snow loaded by shoveling, and found that the former was about double the latter. The machine is ordinarily drawn by four horses.

At the beginning of the winter, 2,400 ft. of snow fences of the Montreal Tramways Co. type, were made at a cost of 34 ct. per lineal foot, and distributed throughout the city.

The quantity of snow which fell last winter in Montreal, according to the reports of the McGill University meteorological bureau, was as follows: November, 3.25 in.; December, 18.4 in.; January, 16.8 in.; February, 18.6 in.; March, 23.2 in.; April, 4.4 in.

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*From a paper presented May 22 before the Canadian Good Roads Congress.

Cost of Reconstructing Oiled Roadways at Los Angeles.—Reconstruction of graveled or oiled roadways at Los Angeles, Cal., is carried on continuously, 11 rollers being assigned to different foremen for this work. Where the surface becomes so worn that minor repairs are not suitable, the street is repaired by rooting, discing, grading, rolling and oiling. The process consists of rooting with a rooting machine pulled by a steam roller. This plowed surface is then disced or pulverized by a discing machine operated by the same power. The street is then heavily sprinkled with water, graded, rolled, re-graded and re-rolled. The surface is then covered by an 81 per cent road oil and sanded. Re-rolling is done where necessary. The cost of the work, according to the 1917-18 annual report of A. C. Hansen, City Engineer, was as follows:

Rooting, 172 miles, at $46.18 per mile.
Discing, 171 miles, at $51.36 per mile.
Rolling, 313 miles, at $46.89 per mile.

4,721 Miles of Surfaced Roads in Florida.—The total mileage of surfaced roads in Florida on Sept. 30, 1918, according to the last annual report of the State Road Department, was 4,721. The figures were compiled from county sources. The mileage of the various types was:

	Mile.
Brick	463
Concrete	8
Asphaltic concrete or shell asphalt	444
Penetration or surface treated macadam	376
Plain macadam	595
Shell	599
Marl or sand clay	2,236

Instructions for Field Inspection of Road Materials

The New Jersey State Highway Department, of which Mr. Wm. G. Thompson is State Highway Engineer, has issued the following instructions for the guidance of its inspectors in sampling and inspecting road materials:

Whenever an inspector is assigned to a job, he will notify the laboratory at once, giving his name, official title, present address, name, location and type of pavement or road, name of contractor, name of resident, county or division engineer under whose jurisdiction the work is to be performed. The inspector will secure as soon as possible from the contractor the source and location of the various materials that will be used. He will notify the laboratory at once, giving the source and location of such supplies. When the materials are purchased from a producer, give name and address of said producer, method of shipment and source of supply; when produced by the contractor, give location of pit or quarry and method of shipment.

Inspector's Equipment.—Each inspector will be furnished with report blanks, stationery, sample bags, shipping tags and the apparatus needed to make the field tests required. The inspector shall secure this equipment before any pavement has been constructed. This equipment is charged to the inspector, who is responsible for its proper care and return to the laboratory when the work is completed. Equipment that is lost, injured or broken will have to be replaced at the inspector's expense, unless the inspector is in no way responsible for said loss or damage.

Size of Samples Required.—The size of the first samples sent of each material shall be as follows:

Portland cement—½ of a large sample bag full.
Sand—⅔ of a large sample bag full.
Stone or gravel—1 large sample bag full.
Brick or asphalt block—15 bricks or blocks.
Granite block—2 blocks.
Fillers for bituminous pavements—½ small sample bag full.
Bituminous cements—1 quart can full.
Liquefier—1 gal. can.

The size of all subsequent samples of these materials shall be as follows:

Portland cement—⅔ of small sample bag full.
Sand—⅔ of small sample bag full.
Stone or gravel—1 small sample bag full.
Brick or asphalt block—1 block of each.
Granite block—1 block of each grade.
Fillers for bituminous pavements—½ of small sample bag full.
Bituminous cement—1 pint can.
Bituminous pavement samples—8 in. to 10 in. square.

Note.—No samples need be forwarded of materials used in macadam or gravel pavements unless the inspector is in doubt whether these materials meet the requirements of the specifications, in which case samples of same should be forwarded in the usual manner.

Samples of Raw Materials Required Before Construction Starts.—Samples of such materials as the inspector has to sample shall be secured before shipment if possible, otherwise sampled at once when the material arrives at its shipping destination.

Whether a material has been previously sampled or not, a sample shall be taken from the first shipment of all Portland cement, sand, stone, gravel, bituminous cement, fillers and paving blocks and forwarded to the laboratory. Duplicate samples of sand, stone or gravel shall be taken at the same time and kept by the inspector for reference until the work is completed.

Samples Required During Construction.

Portland Cement.—A sample shall be taken and forwarded to the laboratory of each car received, and the cement represented by the sample not approved for use until a report is received from the laboratory permitting its use, unless the said material has been previously sampled at the point of shipment or manufacture by the laboratory force. When thus sampled by the laboratory, the inspector shall examine the car and see that the seal is intact, but no approval shall be given by him for the use of this material until a report has been received from the laboratory permitting its use. He will, however, report to the laboratory at once the arrival of all cars thus sealed. The seal used on all cars thus sampled will be marked with a lead seal bearing the inscription "N. J. S. R. Com." The entire sample should be taken from one bag usually near one end of the car. It is well, however, to occasionally take the sample near the car doors.

Sand, Stone and Gravel.—The inspector shall compare each consignement of sand, stone and gravel with the first approved sample. In case any of these materials do not appear to be of as good character or quality as the first sample approved, and the results of the field test subsequently made indicate it is of inferior quality, a sample shall be taken and forwarded to the laboratory at once. A regular sample shall be taken from every 10 or 15 cars of sand received and forwarded to the laboratory regardless of its quality or character.

If the consignment to be sampled is of uniform appearance and grading throughout, one sample may be taken to represent the entire shipment. This sample shall be taken at various points and mixed by rolling on newspapers or canvas. After thorough mixing and so manipulating the paper as to bring the material to an evenly rounded pile, take one-fourth of the sample and with this proceed as before until the quarter last taken is of the proper size for tests. If the consignment to be sampled is not uniform in appearance, then a complete sample must be taken and tested from each grade contained in the shipment.

Paving Block.—Samples of paving block shall be taken during construction only when the quality does not appear to be as good as that of the approved sample, in which case a single block will be mailed to the laboratory for examination.

Bituminous Cement.—A sample shall be taken from each carload received and forwarded to the laboratory at once, and the material represented by the sample not approved for use until a report is received from the laboratory permitting its use, unless the material has been previously sampled at the point of shipment or manufacture by the laboratory force. When thus sampled by the laboratory the inspector shall examine the car and see that the seal is intact, but no approval shall be given by him for the use of this material until a report has been received from the laboratory permitting its use. He will, however, report to the laboratory at once the arrival of all cars thus sealed. The seal used on all cars thus sampled will be marked with a lead seal bearing the inscription "N. J. S. R. Com."

When shipment is made in tank cars, the sample should not be taken until the material in the car has been heated and agitated sufficient to make it uniform in composition. If shipment is made in box cars, a sample must be taken from each lot or batch present as indicated by the batch or lot numbers on the head of the drums or barrels. Additional samples must be taken during the use of all bituminous material whenever the inspector has any reason to believe the cement is not of normal consistency or of an inferior quality as may be indicated by the general appearance of the paving mixture or pavement constructed therefrom.

Bituminous Pavement Samples.—A pavement sample shall be taken of the pavement completed each day, such as warrenite, topeka, amiesite, sheet asphalt, etc. This sample shall be about 8 in. to 10 in. square and shall not be taken until the pavement has received its final rolling, but should be cut out before the pavement has chilled when it belongs to the hot-mixed type. In case a squegee coat is required, a place shall be left unsquegeed and the sample taken at this point.

The inspector at the mixing plant will sample, examine or test, in the matter herein designated, all materials used in preparing the pavement, keep a record of batches prepared each day, the number of loads delivered to the street or road, take the temperature of each load and note the general appearance and character of the paving mixture, also see that the asphalt cement or mineral aggregate is not heated above the limits permitted by the specifications. The maximum and minimum temperatures to which these materials were heated should be recorded and reported each day. Whenever a definite weight of paving material has to be used per square yard of surface pavement, the inspector at the plant will also keep a record of the weight of materials used therein. When materials come from a local sand or gravel pit, the quantity received per day of each shall be roughly estimated.

Paving mixtures that are improperly mixed, have been overheated, or do not have the minimum temperature required by the specifications, or are deficient in asphalt cement or filler, shall be condemned at the mixing plant and the inspector on the road notified to this effect.

The inspector on the road or street will keep a record of each load of paving material received, take its temperature, note its general appearance and report the total number of loads received each day, also observe whether the mixture is of proper consistency to be easily handled when dumped, observe how it consolidates during rolling and note the rapidity with which the rolling is executed after the material has been spread, also whether the rolling is continued until no further evidence of compression is evident. When mixtures are received that do not have the required temperature, are not fairly uniform in composition, or show evidence of careless preparation at the mixing plant, they shall be rejected as soon as the material is dumped and before it has been spread on the road. Special care must be taken to see that no depressions or waves are formed during rolling.

In addition, the foundation should be very carefully examined as the pavement is being spread, and any places that appear to not have the proper density or stability, or appear to be improperly drained, or have been recently rebuilt should be recorded on the daily report blanks. All such reports should be indicated by both the station number and land marks. The pavement samples shall also be taken and forwarded by the inspector on the road. The location of each sample shall be designated by the station number and also a land mark whenever possible.

When bituminous mixtures are purchased by the ton ready for use, the weight of each load shall be taken and recorded by the inspector on the road in addition to the other requirements specified above, and the total quantity received each day recorded.

Concrete Test Cubes.—A 6-in. cube shall be made for each 1,000 sq. yd. of finished concrete surface or foundation, and for each 150 cu. yd. of concrete used in retaining walls, bridge abutments, etc. They shall be taken at proper intervals to space them at approximately equal distances apart. An additional cube shall be made whenever a mix appears to be unusual in any respect, such as, exceedingly wet, improperly mixed, etc. In making the cubes, the inspector will proceed as follows:

See that the equipment is in proper order. The mold should be set on base and leveled carefully. See that it is securely fastened together and that inside surface is thoroughly coated with oil (either heavy lubricating or light cylinder is good).

Fill the mold full of concrete and puddle thoroughly with a steel rod ¼ in. to ½ in. in diameter. The greater part of puddling should be done around the outer edge near the sides of the mold, being careful not to scar the inside surface of mold when pushing rod down into concrete. When properly puddled the cube will be practically free of voids. After puddling fill mold to top again and trowel smooth and level with top of mold.

Place a piece of board or heavy canvas over top to keep off rain or hot sun.

About 24 hours after making, remove mold and mark plainly on side of cube sample number and date made. The inspector will then immediately clean and oil the mold for the next fill.

Place the cube in water and leave it there for six days, after which remove cube from water, wrap in wet newspapers, place inside container and ship to the laboratory.

The same inspector shall make the cubes in all cases to insure uniformity of tamping and other conditions.

It is essential that the above rules be closely followed to insure uniform conditions in making, storing and shipping; otherwise, the concrete cube is worthless for testing purposes.

Forwarding and Reporting Materials.—Samples forwarded either before or during construction must be numbered and plainly marked with the name of the material, road, route or job, and the inspector who forwarded same. All samples forwarded of each material must be numbered consecutively, i. e., Portland cement would be marked 1, 2, 3, etc.; bituminous cement 1, 2, 3, etc.; pavement samples 1-P, 2-P, 3-P, etc., unless more than one pavement sample is taken of the pavement laid during any one day, in which case both samples will have the same general number, but given different index numbers, thus, 7-P^1 and 7-P^2 would indicate that both samples were taken from the pavement laid during one day. Whenever paving-mixture samples are forwarded, they shall be marked 1-M, 2-M, etc., if the pavement is laid in one course only; if laid in two courses, they should be numbered 1-BM, 2-BM, for bottom-course samples and 1-TM and 2-TM for top-course samples.

A separate report must be mailed at once to the laboratory of each consignment of samples sent. This report must be made out on the blank forms furnished therefor and must be filled out in the manner indicated thereon. The samples shall be designated in this report in the same manner as they are marked on the shipping tag, or, in other words, both reports must agree. The written reports must give the location of source of supply of the material, quantity represented by sample, and the purpose for which the material is intended to be used. Also state from where the sample was taken, and, if a special sample, state why it was taken; if taken from a car, the name, number and location of car shall also be given. The location of all pavement samples and date when laid and taken shall also be given. The location of all concrete represented by the cubes forwarded, date cube was made, and proportions of mixture used therein must be definitely stated in the written report.

A daily report must be sent to the laboratory during the actual construction of all bituminous, Portland cement or block pavements. In case work is suspended for any cause, the last report will designate why the work was stopped and when work will be resumed.

Field Tests.

Field tests shall be made on the following materials in the manner designated herein below as soon as each shipment is received.

Concrete Sand.—The sample taken shall be carefully compared with the first sample taken by the inspector and which has been previously approved by the laboratory. After thoroughly mixing, a portion shall be selected to test for organic matter by the colorimetric method described below. The balance of the samples shall be spread out in a thin layer on a paper or piece of canvas, so that it will dry quickly. After the sample has thoroughly dried, it shall then be compared with the inspector's sample. Colorimetric tests shall be made on concrete sands only.

Colorimetric Tests.—Fill graduated bottle to 4½ oz. mark with sand; then fill to 7 oz. mark with sodium hydroxide solution (see directions for preparations in equipment case); shake thoroughly and fill again with solution to the 7 oz. mark; set bottle where it will not be disturbed and shake well several times after filling at intervals of two or three hours. From 20 to 24 hours after filling, compare the color of solution in test bottle with a standard furnished with equipment (see directions in case). In case the solution in the test bottle has developed a darker color than that in the sample bottle, no permit should be issued for the sand represented by this sample. The sample should then be taken and forwarded to the laboratory and a report made in the manner above designated.

Whenever a sieve analysis is required of a concrete sand, proceed in the same manner as specified therefor under "Bituminous Sands."

Bituminous Sands.– Bituminous sands shall be sampled and compared with the inspector's sample in the same manner as specified for concrete sands. The dried sample shall be sieved as herein specified, and the results secured compared with the analyses made by the laboratory on the first sample. Samples taken from the hopper of an asphalt plant shall be quartered and sieved in the same manner as specified for a sand.

Sieve Analyses.– A 200 or 300 gram sample of the dry sand shall be selected in such a manner that it represents the average composition of the sand dried. The bottom pan shall be then attached to the ¼-mesh sieve and the weighed sample poured into this sieve. The sieve shall then be shaken until practically no more material can be made to pass this size sieve. The material retained on the sieve shall then be weighed, the weight recorded and this material discarded.

The material which has collected in the bottom pan shall be transferred to one of the weighing pans or onto a clean paper, the bottom pan adjusted to the next size sieve (10 mesh), the unweighed portion of the sample transferred to this sieve and shaken until practically no more material passes this sieve. The material retained on this sieve is then weighed in the same nammer as before and the operation repeated for each of the various size sieves, using next largest sieve in each case. The material that is finally secured in the bottom pan will be that passing a 200-mesh sieve. The weights secured for the material retained on each sieve should be divided by two if a 200-gram sample is used, or three if a 300-gram sample is used, which will give the per cent of the various sizes of the sand grains contained in the sample.

It is not expected that the results thus secured should agree with the analyses made by the laboratory on the first sample approved, but should not show a variation of over 3 per cent above or below that reported by the laboratory for the material retained on any one given sieve.

Stone, Gravel, or Other Coarse Aggregate.—In addition to general appearance examination to determine whether the quality compares with that of approved sample, the sizes of coarse aggregate must be checked from time to time with the larger sieves having circular openings. With these sieves, proceed as in sieve analyses of sand except, of course, it will be necessary to use a larger sample.

Portland Cement.—There is no field test for Portland cement, except that in cases where the original container has been wet, or, for any other reason, the material contained therein has become hard and lumpy, no permit will be issued for cement of this character.

Bituminous Cement.—The only field test to be made on bituminous cement is to check up the consistency, or, in other words, determine the penetration the material has at 25° C. (77° F.). To make this test a 3-oz. can is filled nearly full of hot asphalt cement. When cooled to nearly normal temperature, it should be set in a pan containing sufficient water to completely cover the can. This water should be kept at 25° C. for about one hour. The specimen is then removed from the water and placed on the platform of the penetration machine. The needle is then adjusted so its point just touches the surface of the asphalt cement and the plunger released for a period of five seconds. The readings on the dial, which was previously set at zero, will show the distance in millimeters, the needle penetrated. This shows the consistency of the asphalt cement and should agree with the limits defined therefor in the specifications.

Bituminous Pavement Samples.—All pavement samples cut should be carefully examined to see if they have the thickness and density required by the specifications. If the paving mixture was at normal temperature when spread (about 300° F.), the general appearance of a clevage face of the pavement will give a fair idea whether the bituminous content is correct or not. No other field tests are required on pavement samples.

Bituminous Mixtures.—The temperature of these mixtures should be taken and general appearance when dumped into the wagon observed. If the mixture is at normal temperature (about 300° F.), it should have a bright and lively appearance if it contains the required quantity of asphalt cement. If it is deficient in asphalt cement, it will have a dull color, being more plastic and stiffer than a mixture containing the required quantity of asphalt cement. When a mixture is too rich in asphalt cement, it will be very soft and sloppy.

The paper-pat test is a more reliable method of determining the asphalt content of a paving mixture in the field than to judge the asphalt content of these mixtures by their general appearance. This test is made in the following manner:

Bituminous Pat-paper Test.—To make a pat-paper test, a small quantity of the bituminous mixture (about 200 grams), having a temperature of about 300°, is placed on one-half of the pat-paper and the other half turned over on the top of the mixture and gently tapped down thereon three or four times with a small wooden block or paddle until the bituminous mixture has a thickness of about ½ in. The paper should also rest on a wooden board or block in order that the paving mixtures will not cool quickly. The top paper is then gently pulled away from the bituminous mixture. If the mixture is deficient in asphalt cement, very little stain will appear on the paper; if too rich in asphalt cement, a decisive coating will be left on the paper; if the per cent of asphalt cement is about right in the paving mixture, a distinct impression will be left on the paper but not enough to make a coating.

This test should never be made on a mixture that has a temperature less than 275° or over 325° F., otherwise the asphalt stain on the paper is of little value in determining whether the mixture contains the right amount of asphalt cement or not.

The "Sand" Method of Proportioning Pit Run Gravel for Concrete

Although screened and remixed aggregates for concrete are preferable to pit-run gravel, still in many localities large amounts of the latter material are used. An investigation to establish engineering methods for the proper use of such material has been conducted by the Engineering Experiment Station of the Iowa State College, at the request of the Iowa State Highway Commission, and the present specifications of the Commission for the use of pit run gravel are based upon this cost. The results of this investigation were set forth by Mr. R. W. Crum of the Experiment Station in a paper presented June 27 at the 22d annual meeting of the American Society for Testing Materials. The matter following is abstracted from Mr. Crum's paper.

The material considered in the paper is pit-run gravel, to be used without change as it comes from the pit. The problem is to establish some relation between grading and the amount of cement such that, for mixtures of the same plastic consistency, concretes of equivalent strength could be designed.

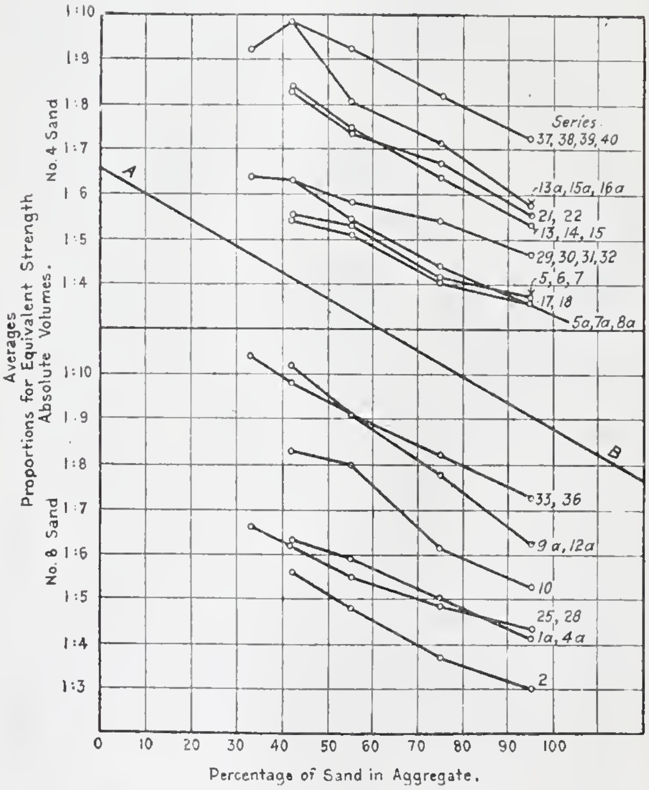

Fig. 1—Relation Between Percentage of Sand in Gravel and Theoretical Proportion by Actual Volume.

To establish such a workable relation, it is necessary to express the grading of the gravel by numerical functions. Other experimenters, notably Abrams and Edwards, have done so, and their work could be used as a basis for proportioning pit-run materials. However, both Abrams' "Fineness Modulus" and Edwards' "Surface Area" method require the making of a complete sieve analysis of the material. The method described below requires the separation of a sample into only two sizes and a simple determination of the weight per cubic foot of the loose gravel.

The principal conclusion resulting from the investigation carried out is that the grading of pit-run gravel may be measured by the rato of fine aggregate to total aggregate (that is, percentage of fine aggregate in total) and by the weight per cubic foot of the material, measured loose. For purposes of commercial convenience the dividing line between fine and coarse aggregate is taken on the common No. 4 sieve. In the following discussion, fine aggregate as defined above will be called "sand," and coarse aggregate "pebbles."

Two assumptions have often been made by users in proportioning the cement to pit-run gravels:

1. That the ratio of cement to total aggregate should be a constant.
2. That the ratio of cement to the sand portion of the aggregate should be a constant.

The former is wrong and on the unsafe side. The latter is also wrong but is on the side of safety.

Obviously, neither the ratio of cement to total aggregate, nor the ratio of cement to the sand portion, should be a constant, but for equivalent mixtures the ratio of cement to total aggregate should increase in some relation to the percentage of sand in the gravel. That this is a straight line relation is demonstrated below:

Theory for Making Concretes of Equivalent Strength Using Gravels of Varying Sand Content—The "Sand" Method.—This theory depends upon the assumption that there is a direct relation between the strength of concrete and the ratio

$$\frac{c}{1-(c+s+p)} = \frac{c}{1-d}$$

in which c = absolute volume of cement, s = absolute volume of sand particles, and p = absolute volume of pebbles in a unit volume of freshly made concrete; d = coefficient of density = absolute volume of solid material in a unit volume of freshly made concrete = c + s + p; and 1 — d = volume of air and water voids.

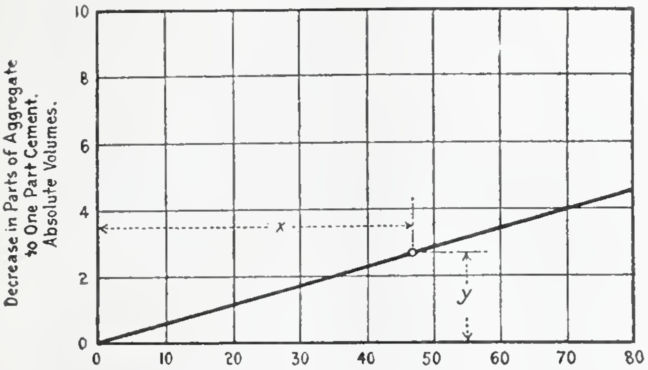

Fig. 2—Diagram for Use in Determining Proportions to Use with a Given Material Having a Certain Sand Content.

To determine amount of cement to use with a given pit-run gravel to yield a concrete equivalent to a given mixture of sand and gravel:

(1) Reduce the proportion of the standard mix to the basis of absolute volume.

(2) Determine from curve decrease in parts of aggregate corresponding to increase in percentage of sand in aggregate.

(3) Change the absolute volumes thus found to the loose volume basis.

Formula for computing Item 2:

$$\text{tau a} = \frac{3.6}{62} = 0.058 \quad \text{(see A B, Fig. 1.}$$

$$y = x \text{ tau a} = 0.058x.$$

By absolute volume of a granular material is meant the actual sum of the volumes of all of the particles; it is expressed as the fractional part of the total space occupied by the material.

In order to compute proportions for equivalent strength, it is necessary to assume for each class of concrete that some mixture is satisfactory. For the three classes of concrete conidered in this paper, the following mixtures were taken as the basis:

Class I—Prportion 1 : 4½, gravel containing 42 per cent sand.

Class II—Proportion 1:5½, gravel containing 42 per cent sand.

Class III—Proportion 1:7, gravel containing 42 per cent sand.

Taking each series of tests by itself, the probable proportions to use with the different percentages of sand in the aggregate, to yield concrete equivalent to the one having 42 per cent of sand in the aggregate, were derived as follows:

DATA CONCERNING PROPORTIONS FROM TYPICAL SERIES.

Per cent of sand in aggregate, by weight.	c	s	p	d	$\frac{c}{1-d}$
33	0.096	0.227	0.440	0.763	.....
42	0.105	0.286	0.378	0.769	0.455
55	0.122	0.361	0.282	0.765	.....
75	0.132	0.456	0.145	0.733	.....
95	0.167	0.525	0.026	0.718	.....

To arrange the proportions for equivalent strength it is necessary to so change the relation between the absolute volumes of cement and aggregate that the ratio $\frac{c}{1-d}$ will in each case become equal to 0.455. The adjustment can be made by increasing or decreasing c and decreasing or increasing s + p, so that d will be unchanged, thus:

let c', s' and p' be the new values required for c, s and p, respectively. As explained above, these values are the percentages of absolute volumes of the materials in a unit volume of freshly made concrete.

$$\frac{c'}{1-d} = \frac{c'}{1-(c'+s'+p')} = 0.455$$

Therefore, to convert the mixture containing 33 per cent of sand:

$$\frac{c'}{1-0.763} = 0.455$$

$$c' = 0.108$$

$$d = c' + s' + p'$$

$$0.763 = 0.108 + (s' + p')$$

$$(s' + p') = 0.655$$

Accordingly the ratio of absolute volume of cement to absolute volume of total aggregate, required to make a proportion using the 33-per-cent sand mixture equivalent to the 42-per-cent mixture is

108 : 655, or 1 : 6.7

New proportions for the 55, 75, and 95-per-cent mixtures were computed in the same way.

This theory is approximate, not rigorous, for when the concrete is actually made, the density d will be affected a small amount. The result obtained, however, is within the probable range of accuracy in making the concrete.

The proportions thus derived are by absolute volumes. To make these proportions usable it is necessary to convert them to a loose volume basis, which requires the weight per cubic foot of cement and loose aggregate. Assuming cement to weigh 94 lb. per cu. ft., its specific gravity = 3.14, and that of the aggregate = 2.68, absolute volume proportion of aggregate (cement 1) may be changed to loose volume proportion by the following equation:

$$\text{Aggregate (loose)} = \frac{\text{Aggregate (absolute)} \times 80}{\text{Weight per cu. ft. of aggregate (loose)}}$$

In this way the absolute proportions and loose volume proportions of materials to yield concrete equivalent in strength to the one in each series whose aggregate contained 42 per cent of sand, was determined for aggregates containing 33, 55, 75, and 95 per cent of sand.

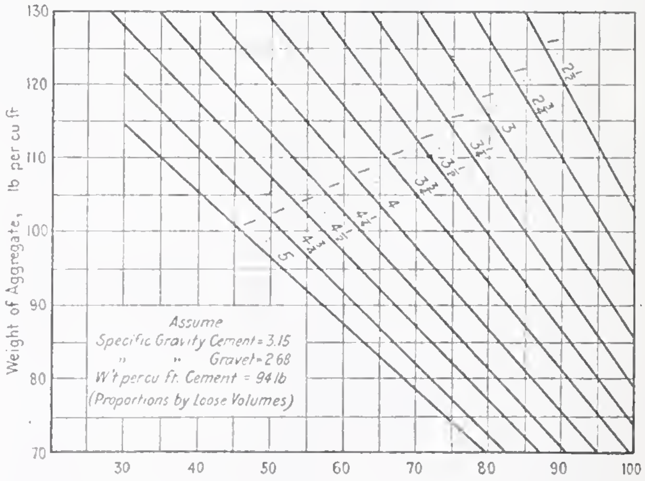

Fig. 3—Diagram for Use in Proportioning Pit-Run Gravel for Class I Concrete.

In Fig. 1 the relation between the proportions for equivalent strength by absolute volume, and percentage of sand in aggregate, is shown for all of the specimens tested. Each line is the average of results from 3 or 4 different sands, and therefore represents the conclusion drawn from 3 or 4 series of tests. Each point is the average of from 75 to 100 individual specimens.

The conclusion drawn from a study of this diagram is this:

The relation between proportions by absolute volumes to give equivalent strength, and sand content of the aggregate, varies uniformly and at approximately the same rate for all degrees of quality of concrete. The line AB in the diagram is established to indicate this rate of variation as an average.

To make use of this diagram to determine the proportions to use with a given material having a certain sand content, it is necessary first to assume an aggregate and proportion known to be satisfactory. Locate the point representing this known condition and draw a line through it parallel to AB. Then pick from this line of proportions the proportion corresponding to the given aggregate.

To make a single line diagram of general application, the line AB (Fig. 1) is plotted on Fig. 2, using for ordinates the decrease in parts of aggregate, and for abscissas the increase in percentage of sand in the aggregate. This diagram can be used for determining proportions in a case when the proper data are at hand, or for writing a table of proportions for equivalent mixtures of cement and pit-run gravels in general. Such a table could not be exact for all materials, but it would give a very reasonable set of proportions to use with Iowa gravels.

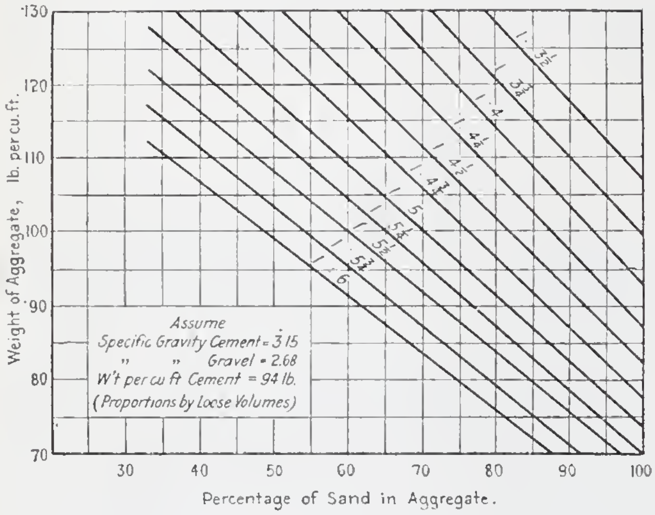

Fig. 4.—Diagram for Use in Proportioning Pit-Run Gravel for Class II Concrete.

TABLE 1—PIT-RUN GRAVEL CONCRETE PROPORTIONED BY THE SAND METHOD.

			Characteristics, mixed aggregate.				Proportions.					
Concrete class.	Series No.	Material.*	Percentage of sand.	Weight, lb, per cu. ft.	Fineness modulus.	Surface area, sq. ft per 100 lb.	By weight.	By absolute volume.	By loose volume.	$\frac{c}{1-d}$	Percentage of water in mix, by weight.	Compressive strength at 28 days, lb. per sq. in.
I	48	..	33	113.9	533	819	1:6.06	1:6.6	1:5	0.374	10.0	1479
		..	42	114.7	501	978	1:5.49	1:5.92	1:4.5	0.414	10.0	1945
		..	55	117.5	458	1220	1:4.97	1:5.87	1:4.0	0.403	10.6	2425
		..	65	115.7	424	1398	1:4.61	1:5.0	1:3.75	0.426	10.3	2465
		..	75	113.6	392	1575	1:4.23	1:4.60	1:3.5	0.428	10.9	2565
		..	85	109.3	360	1753	1:3.78	1:4.10	1:3.25	0.433	11.3	2580
		..	95	106.9	327	1931	1:3.41	1:3.7	1:3	0.434	12.3	2160
II	49	..	33	113.9	533	819	1:7.27	1:7.90	1:6	0.308	10.1	1343
		..	42	114.7	501	978	1:6.71	1:7.28	1:5.5	0.340	9.6	1920
		..	55	117.5	458	1220	1:6.25	1:6.79	1:5.0	0.343	10.2	1800
		..	65	115.7	424	1398	1:5.54	1:6.01	1:4.5	0.363	10.3	1955
		..	75	113.6	392	1575	1:5.11	1:5.58	1:4.25	0.367	10.6	2135
		..	85	109.3	360	1753	1:4.65	1:5.06	1:4	0.356	11.7	2005
		..	95	106.9	327	1931	1:4.26	1:4.63	1:3.75	0.373	12.4	1860
III	50	..	33	113.9	533	819	1:8.78	1:9.52	1:7.25	0.269	9.4	1113
		..	42	114.7	501	978	1:8.54	1:9.26	1:7.0	0.284	9.5	1315
		..	55	117.5	458	1220	1:8.13	1:8.82	1:6.5	0.270	9.9	1415
		..	65	115.7	424	1398	1:7.38	1:8.14	1:6	0.287	10.1	1416
		..	75	113.6	392	1575	1:6.95	1:7.54	1:5.75	0.263	11.2	1225
		..	85	109.3	360	1753	1:6.40	1:6.93	1:5.5	0.263	12.3	1059
		..	95	106.9	327	1931	1:5.87	1:6.38	1:5.0	0.260	13.7	1031
I	46	..	33	115.6	494	756	1:6.15	1:6.8	1:5	0.447	8.8	3120
		..	42	115.0	468	915	1:5.50	1:6.3	1:4.5	0.490	8.6	3290
		..	55	114.4	431	1142	1:4.87	1:5.53	1:4.0	0.536	8.8	3260
		..	75	112.5	374	1495	1:4.16	1:4.73	1:3.5	0.602	9.3	2970
		..	96	102.5	320	1839	1:3.27	1:3.8	1:3	0.604	10.8	3090
III	47	..	33	115.6	494	756	1:9.22	1:10.3	1:7.5	0.231	7.7	2000
		..	42	115.0	468	915	1:8.56	1:9.7	1:7.0	0.293	9.1	1816
		..	55	114.4	431	1142	1:7.91	1:9.0	1:6.5	0.316	9.25	1950
		..	75	112.5	374	1495	1:6.88	1:8.0	1:5.75	0.334	10.6	1580
		..	95	102.5	320	1839	1:5.45	1:6.3	1:5.0	0.371	11.0	1760

*Material used—I 48, II 49 and III 50: Sand, No. 21; pebbles No. 23. I 46 and II 47: Sand, No. 20; pebbles No. 22.

EXAMPLE.

Assume that an aggregate containing 42 per cent of sand, and weighing 112 lb. per cu. ft., makes a satisfactory concrete in the proportion 1:4½ loose volume. What proportion should be used with a similar gravel containing 75 per cent of sand and weighing 107.1 lb. per cu. ft.?

Change the proportion 1:4½ to a proportion by absolute volume, thus:

$$\frac{4.5\times112}{80} = 6.3. \text{ Proportion (absolute)} = 1:6.3.$$

The increase in percentage of sand is 33. From Fig. 2 the corresponding decrease in parts of aggregate is 1.9. 6.3 — 1.9 = 4.4. Therefore, the proportion for the aggregate containing 75 per cent sand should be 1:4.4, absolute volumes, or 1:3.3 loose volumes.

Fig. 2 is perfectly general and can be used for designing mixtures equivalent to any assumed base.

The diagrams in Figs. 3, 4 and 5 have been arranged for convenience in proportioning pit-run gravels for three classes of concrete:

Class I, suitable for reinforced concrete in general, watertight concrete, and base course of concrete pavement. It should range in strength from 2400 to 3000 lb. per sq. in.

Class II, suitable for first class foundations, gravity section piers and abutments for bridges, and base course of nonreinforced floors and walks. It should range in strength from 1800 to 2400 lb. per sq. in.

Class III, suitable for large foundations and heavy mass work in general. It should range in strength from 1200 to 1800 lb. per. sq. in.

Verification.—Table 1 shows the resulting strengths of laboratory specimens made in accordance with the foregoing principles. It is believed that these results verify the reasonableness of the method of proportioning pit-run gravels described. Series Nos. 48, 49 and 50 were made about one year after series Nos. 46 and 47 from different materials, and by a different operator. The consistency was approximately the same in both groups.

Application.—The mere fact that pit-run gravel is ordinarily not a well-graded material, is not an insuperable obstacle to its use. All that is required is its use with the right amounts of cement and water. The principal difficulty is the fact that the product of a pit is often extremely variable as regards grading. Nevertheless large amounts of this material are being used, and since in many cases great economy results from its use, it would seem that engineers should be prepared to lay down rules for the proper handling of this material.

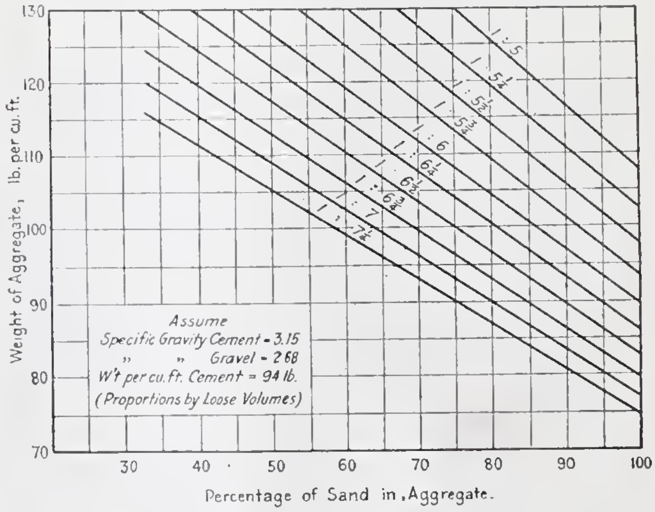

Fig. 5—Diagram for Use in Proportioning Pit-Run Gravel for Class III Concrete.

An important advantage of the method of proportioning described in the paper is the simplicity of the field tests required. The percentage of fine aggregate (or sand) in the gravel, and the weight per cubic foot, can easily be determined with simple apparatus.

In practical use, frequent analysis must be made and the proportions changed as often as is necessary to agree with the variations in the material.

Cost of Maintaining City Owned Teams

Interesting data on the maintenance of horses by municipal departments are given in a recently issued report by the Rochester Bureau of Municipal Research, Inc., on the collection of refuse in the city of Rochester, N. Y.:

Cost of Maintaining Horses at Columbus, O.—According to the report of Superintendent E. W. Stribling, of the Division of Garbage and Refuse Collection, the cost of maintaining 142 horses by the city of Columbus, O., in 1916 was 83.7 ct. per horse per day. This included a cost of 41.63 ct. for feed; 13.53 ct. for veterinary services, shoeing and supplies; and 28.54 ct. for stable labor. In 1915 the unit cost was 83 ct. per horse per day, including 45.77 ct. for feed, 11.98 ct. for veterinary services, shoeing, and supplies and 25.25 ct. for stable labor. The labor force consisted of 16 men and a night watchman. The cost of feed was about $14 per ton for hay, 75 ct. per bushel for corn and 50 ct. per bushel foi oats. Straw cost about $7 per ton. In 1916 each horse consumed daily 30 lbs. of hay, and 13 lbs. of grain, 5.3 lbs. of straw were used in bedding each horse. In 1915 these quantities were 31 lbs , 12.75 lbs., and 6.3 lbs. respectively.

Cost of Horse Maintenance at Cincinnati.—Similar costs for 1916 in the city of Cincinnati, given in the report of Fred Maag, Superintendent of the Department of Street Cleaning, Sewer and Catch Basin Cleaning, indicate that 34.9 ct. per horse per day was the cost of feeding and 39.4 per ct. was the cost of "other stable expenses," the total cost being 74.3 ct. per horse per day. Approximately 190 horses and 80 mules were maintained in 17 stables, practically one-half of this number being boarded in one stable. Each horse consumed 14.7 lbs. of hay, 11.5 lbs. of oats and 2.8 lbs. of nutritia daily. Hay cost about $18 per ton, oats 45 ct. per bushel and nutritia $1.50 per hundredweight. (No allowance apparently was made for bedding straw.)

Cost of Feeding Horse at Washington.—In Washington, D. C., according to the report of the Engineering Department for the fiscal year, 1915-16, the cost of feed amounted to 40.2 ct. per horse per day. The daily allowance per hoise was 3.3 lbs. of dry straw, 7 lbs. of long timothy, 7 lbs. of mixed clover hay, 12.8 lbs. of oats and 1.7 lbs. of bran. Straw cost at the rate of $16, long timothy at $20.80 and mixed clover hay at $20 per ton, oats at 54 ct. per bushel and bran at $1.27 per hundredweight. The cost of shoeing was stated to be 2.6 ct. per horse per day.

Cost of Maintaining Horses by New York Street Cleaning Department.—In the annual report of the Department of Street Cleaning of New York, in 1916, Commissioner J. T. Fetherston states that the cost of "labor, materials, supplies and consumable equipment used directly in the care of horses" amounted to $1.087 per horse per day and that this cost represents prices of forage and supplies considerably above normal. About 64 per cent of the total cost represents the cost of forage, 30 per cent the direct labor cost and 6 per cent the cost of maintaining stable equipment. In the 26 stables maintained by the department; 2,400 horses were cared for One hostler and one stableman were employed for each 13 horses. In 1917, the daily allotment for each horse was 23 lbs. of oats, 18 lbs. of hay, 3 1/7 lbs. of bran and 3 lbs. of straw. In addition to this each horse was given 1½ lbs. of coarse salt and 2½ lbs. of rock salt per month. When idle the horses were given half ration of oats. In 1916, the daily ration was 21 lbs. of oats, 15 lbs. of hay and 1 1/7 lbs. of bran. The other items were practically the same as for 1917. This appears to be an unusually heavy ration and the cost of feed alone was practically 70 ct. per horse per day.

Stable Costs at Rochester.—For Rochester it was possible to obtain from James M. Harrison, formerly superintendent for the Genesee Reduction Co., data of the cost of maintaining horses employed in garbage collection from 1908 to 1916. On Jan. 1, 1917, the Department of Public Works took over the operation of the garbage plant stables and the 1917 costs, therefore, are available also.

In 1917 the 68 horses quartered at the garbage plant stables cost about 68 ct. per horse per day to maintain. The approximate cost of feed amounted to 50.7 ct.; the direct labor cost of stable operation, 9.4 ct.; and the estimated cost of barn supplies, shoeing and harness repairs, 7.9 ct. per horse per day. No exact ration allotment was made, but according to the total quantities purchased during the year each horse consumed about 11 lbs. of oats and 22 lbs. of hay per day. The approximate average cost of oats was 80 ct. per bushel and the cost of hay was about $18 per ton. The stable force consisted of one barnman and three helpers, the barnman and one helper working seven days and the other two helpers six days per week. The drivers cleaned and harnessed the horses and gave them their noon feeding.

The foregoing data and certain additional data as to the cost of maintaining horses by the Genesee Reduction Co. before 1917, are shown in Tables I and II.

From the foregoing and other data it appears that a horse used in collection work should be fed on the average about 20 lbs. of hay and 14 lbs. of oats per day, in addition to possibly 2 lbs. of other feed, consisting principally of bran, salt, etc. Also each horse should be bedded with approximately 5 lbs. of dry straw daily. On this basis and with hay costing $18 per ton, oats 80 ct. per bushel, other feed $1.50 per hundredweight and straw $12 per ton, the total daily cost per horse of feed and bedding would amount to the following:

20 lb. of hay at $18 per ton	$0.18
14 lb. of oats at $0.80 per bu	.35
2 lb. of other feed at $1.50 per cwt	.03
5 lb. of straw at $12 per ton	.03
Total estimated cost of feed and bedding per horse per day	$0.59

In addition to this the cost of veterinary services, maintenance of stable equipment and supplies, shoeing, and harness repairs should not exceed 12 ct. per horse per day. If one hostler at $800 per year and one stableman at $750 per year were provided for every 20 horses, the direct labor cost of stable operation would amount to about 21 ct. per horse per day. This would include the cost of all work involved in feeding, bedding, cleaning and otherwise caring for horses, and all labor about the stables such as cleaning stables, handling feed and supplies, handling and moving equipment, cleaning equipment, etc.

The total cost per horse per day, therefore, might be estimated at 92 ct., distributed as follows:

Feed and bedding	$0.59
Veterinarian, shoeing, harness repairs, etc	.12
Direct labor cost of stable operation	.21
Total maintenance cost per horse per day	$0.92

The annual cost of maintaing horses at this figure would be $336.65 per horse, exclusive of the cost of overhead supervision; fixed charges on first cost of horses, stable sites and stable buildings, depreciation of horses, and depreciation and maintenance of stable buildings.

The annual (purchase) cost of the horses used in garbage collection in Rochester since 1912 has been about $31 per horse, which includes replacements as well as the purchase of three horses during the six years in addition to the number owned at the beginning of the period. [See Table II].

TABLE I—COST OF FEEDING HORSES EMPLOYED IN THE COLLECTION OF GARBAGE IN ROCHESTER, N. Y., 1908 TO 1916.

Year.	Total cost of feed (grain, hay, straw)	Approximate number horses fed.	Average cost per horse per day.
1908	$ 7,364.08	10	$0.505
1909	6,964.89	40	.477
1910	6,912.67	40	.474
1911	6,827.04	40	.467
1912	7,816.29	65	.330
1913	9,269.83	65	.395
1914	8,771.77	65	.370
1915	10,666.02	66	.443
1916	9,570.47	66	.397

TABLE II—COST OF RENEWALS OF HORSES EMPLOYED IN THE COLLECTION OF GARBAGE IN ROCHESTER, N. Y., 1912 TO 1917.

Year.	Total expenditure for horses.	Approximate number of horses.	Average cost per horse per year.
1912	$2,219	65	$34
1913	1,885	65	29
1914	4,205	65	65
1915	1,020	66	15
1916	1,575	66	24
1917	1,125	68	17

Estimates as to the economic life of a horse used in collection work vary from 4½ to 8 years. It is believed, however, that a good horse should give at least six years of useful service in this kind of work. Assuming a first cost of $275 and a salable value of $75 at the end of six years, the annual depreciation would be $33.33 per year per horse.

$900,000 Highway Contract in Illinois.—The State Highway Department of Illinois has awarded a $900,000 contract for constructing a section of the Springfield-Carlinville highway. The contract covers 40 miles of highway. James Black Masonry Co., Chicago, Ill., is the contractor.

Water and the Subgrade*

By J. L. HARRISON,
Highway Engineer, Bureau of Public Works.

The development of the heavy truck has brought to the front a number of problems in highway design which demand consideration, but of these none are of more pressing importance than those which arise in designing the subgrade of a modern highway. This is because as a structure the subgrade is less reliable than the pavement that is laid on it, with the result that more money must be expended on the pavement than would be necessary if the stability of the subgrade could be so adjusted that its supporting power would become a reasonably uniform quantity.

There have been some efforts to develop the supporting power of the subgrade into a known quantity, and textbooks on highway engineering have generally recognized the need of improvement in this particular by urging that one of the most important considerations in the design of a highway is that the subgrade be kept dry, there being in this presentation of the matter two obvious assumptions, first, that it is possible to keep the subgrade dry, and, second, that if the subgrade is kept dry it will have a supporting power of such uniform quantity that it will offer a reliable foundation for any pavement which is laid over it.

These assumptions are interesting because the last is almost unquestionably the result of the common experience that during the summer months when subgrades are relatively dry their carrying capacity (except in the case of sands and gravels) is higher than when they are wet. On the other hand, the first assumption seems to have arisen from the logical deduction that by keeping subgrades dry the strength and the comparative uniformity of supporting power which subgrades show during the summer months would persist throughout the year.

Drainage Often Fails to Get at Real Seat of Trouble.—For some reason there has been connected with this obvious deduction the idea that an impervious pavement and proper drainage will produce the desired condition of the subgrade. However, the emphasis which has been placed on proper drainage as a factor in producing this result has been greater than the facts warrant, for drainage, in the strict sense, deals only with the removal of that water in the soil and on its surface which is subject to the action of gravitation. But under many conditions the water which is causing trouble in a subgrade is held in the soil in spite of the action of gravitation. Therefore drainage, no matter how complete, often has been unsatisfactory, for it has quite generally failed to get at the real seat of the trouble. On the other hand, this fact did not become as conspicuous when light loads were moved over the pavements as it has become since heavy trucks came into common use.

Subgrades are constructed of all sorts of soil, the general practice being to build subgrades of whatever soil happens to be on the right of way. As a result of this practice, the soils found in ordinary subgrades vary from rock and coarse gravel to clays which are so fine that much of the kaolin of which they are largely composed exists in a colloidal state. But all soils contain moisture, and here lies the great difference in the behavior of different soils under the same conditions of drainage, for part of the moisture in these soils is moved by gravitation and part by capillary attraction. (We have no particular interest in that part of the moisture content of soils which exists as surface films on the soil particles.) It is a well-known fact that the percentage of pore space in different soils does not vary over a very wide range, but the size of the pores varies a great deal. In coarse gravel the pores may be quite large, in clay they are very small. Practically all of the water which exists in gravel is gravitational—that is, moved by gravity—while in a very fine clay, as fire clay, whatever free water is present is capillary water, there being almost no gravitational water at all. Between the coarse gravels and the fine clays, which are used as types because one contains practically no water held by capillary attraction and the other almost none that is subject to the action of gravitation, lie most of the soils used in constructing highway subgrades. Unfortunately, these soils tend to resemble the clays more than they do the gravels.

Where Drainage Fails.—It is not surprising, therefore, to find that the soils ordinarily used in highway subgrades contain a good deal of water which is held there by capillary attraction—water which can not be "drained" out by the installation of any sort of a drainage system for it is not moved by gravitation. Nor, then, should it be surprising to find that ordinary drainage systems—open ditches and tile drains—so commonly fail to produce reasonably dry subgrades, for the amount of water which normal soils will absorb and hold in spite of the action of gravitation is often sufficient to reduce the carrying capacity of such soils to a point far below their supporting power when they are dry. Indeed, in the case of clay the contained water held without regard to gravitation may exceed 50 per cent of the total volume of the clay mass. This is, of course, enough to render the mass too plastic to be depended on to carry heavy loads. Other soils, depending largely on the amount of clay in them, have this same power of absorbing and retaining water; that is, they can absorb and retain until it is dried out of them by contact with the air quite enough water to materially reduce their load supporting power.

When such soils are used in highway embankments the water so absorbed is commonly obtained in one of two ways, from (1) the normal precipitation on the shoulders and slopes of the highway from which areas it is distributed through the subgrade by capillary attraction and from (2) the water table which underlies the highway, from which level it is raised into the subgrade by this same force. Modern practice in highway design almost always leaves the shoulders and the slopes open to the rain and, more frequently than is generally supposed, the water table is close enough to the surface of the ground so that capillary attraction will raise water into the subgrade.

Rainfall and Soft Subgrades.—The normal rainfall on the shoulders and slopes of a subgrade is not usually looked at as the cause of any trouble with soft subgrades though it is, in fact, quite often responsible for such trouble. The percolation of water into the soil is a large subject by itself, but a number of the salient features may deserve notation in this connection. One of these is that while water percolates very slowly into a soil which is so dry that the films of moisture which normally surround the particles in the soil have been largely removed, it moves quite rapidly where the soil is moist. Moreover, percolating water moves both down and out, the outward movement being negligible when the pores in the soil are so large that the movement of the water is largely by gravity, but quite high when the movement is by capillary action. It therefore transpires that during a protracted rain, particularly in the spring when the soil is apt to be moist at all times, dense clay subgrades may, and, in fact, do absorb a large amount of the rain which falls on the shoulders and that this absorption may carry the water considerable distances under the edges of the pavement.

The moisture so absorbed is retained very persistently by the finer grained varieties of clay. In fact, it is no uncommon thing to find that, under the pavement, the pockets of such clays as fire clay or dense blue clay are quite plastic for weeks after ordinarily porous material has dried out to a point where a satisfactory bearing power has been developed. Many failures on hard surface pavements are due to the presence of pockets of materials of this sort, materials which, when protected by a relatively impervious pavement, retain enough moisture so that with what is absorbed through the shoulders and slopes during every rain they never become dry enough to be stable. The writer has seen fire clay taken from such pockets in July which was as plastic as good putty—the moisture in this clay having been prevented from direct evaporation by a bituminous concrete pavement, and the moisture which was drawn away by capillary attraction to make up for the evaporation from the shoulders having been resupplied from time to time by the rain which fell on the shoulders and slopes of the highway.

Clay Subgrade Near Water Table.—In the case of a water table which is near the surface of the ground a similar condition prevails. Water is raised by capillary attraction through various heights, materials through which this force will raise water 2 or 3 ft. being common, while materials through which capillary attraction will raise water as much as double these heights are by no means rare. The presence of a large amount of clay in a sub-grade which is within 6 ft. of a water table is, therefore, an invitation to trouble, for there are a great many clays which will absorb enough moisture under conditions of this kind to remain constantly plastic if their moisture content is protected from evaporation by an impervious pavement.

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*From Public Roads.

In this connection there is one point which deserves mention: the moisture content in the top layer of the soil is the result of two opposing conditions, the rate of evaporation and the rate at which moisture is supplied from below by capillary attraction. In an open field the surface of the ground may become very dry during the day, due to a high rate of evaporation, and then may become quite moist during the night because the rate of evaporation has fallen very low while the rate at which moisture is being raised by capillary attraction has remained constant. Through a pavement, on the other hand, there is obviously almost no evaporation, so a pretty constant moisture content may be maintained in the subgrade just below it by even a low rate of capillary flow, there being no need to supply moisture faster than the normal rate of capillary flow from the interior of the subgrade to the shoulders, to keep up a condition of high moisture content under the pavement. That this condition prevails more often than is generally supposed is evident from the fact that during his investigations of this matter the writer has encountered moisture contents as high as 18.88 per cent by weight (about 60 per cent by volume) and has found that 30 per cent of water by volume is quite a common moisture content in the clay immediately under an impervious pavement. Of course, any clay in a road embankment which contains as much water as this is so plastic that it cannot be depended on to carry very heavy unit loads.

The obvious remedy for this condition of affairs is to use less clay in highway subgrades. For this reason the modern practice of balancing cuts and fills is to be regretted, for while economical as to first cost it carries with it the constant temptation to use a great deal of material which should never form a part of a highway embankment. To what extent it will be advisable to waste material which is now regularly used will depend very largely on what loads the highways are ultimately to be called on to carry, but, as the data now at hand serves to show that many of the clays act very much like sponges and absorb so much water that they are plastic much if not most of the time, the rejection of many of the clays would seem to be advisable if anything like uniform stability is to be secured in a subgrade.

Drains Not Always Effective.—The advocates of tile drainage, as a panacea for all of the ills that befall pavements, will argue that much can be done by using tile drains if the tile drains are placed deep enough. Tile drains can be so placed, it is admitted, that they will lower the water table. If placed from 6 to 8 ft. or more below the surface they would probably stop most of the water now raised into the subgrade by capillary action. On the other hand the writer has found as high as 11.2 per cent of moisture by weight (about 30 per cent by volume) in a clay soil under an asphalt pavement (2-in. asphalt top on a heavy concrete base) where the water table was so far below the surface that a service opening 10 ft. deep had not yet encountered it.

This would seem to indicate that there are times when water is raised a long distance, for there did not appear to be any other source from which this moisture could have come. The sheet asphalt pavement precluded any assumption that this water had come through the pavement. The sidewalks are of concrete and the building space for hundreds of feet in all directions is under roof. The obvious conclusion is that where there is no direct evaporation and where there is no shoulder evaporation, water either may be gradually lifted to heights much above the ordinary limit of capillary attraction or that condensation on the under side of the pavement may eventually develop a high water content in the underlying soil, if this soil is dense enough to retain moisture.

In any case the use of tile drains to unwater clay subgrades is pretty largely a waste of money, for clay as it is compacted into a highway subgrade cannot be unwatered in this way unless the tiles are placed deep enough to keep the water table beyond the range of capillary attraction, which means that to accomplish the desired results the tile must be placed much deeper than is now common and even then the results will be very doubtful. Indeed this should be clear for another reason. Clay is so impervious that it is constantly used to make cofferdams watertight. In the construction of cofferdams a thickness of a very few feet of clay is often used to hold back a considerable head of water. Used in this way, clay is a standard construction material. Just why, then, engineers should try to drain this same material by running a few tiles through it is not clear. A clay subgrade may contain a large amount of water, but this water is contained in pore spaces which are so small that gravity is not strong enough to overcome the capillary attraction which holds it in these pores, so little or no good attends the use of tile drains in such material, except as such drains are used to cut off the supply from which the water in the wet strata is drawn.

Problem in Spring Thaws.—Another phase of the general problem of dealing with water in the subgrade is presented by the spring thaws. It is a notorious fact that at this time of the year subgrades, especially in northern regions, are more apt to give trouble than at any other time. The cause is not hard to locate, but the undesirable conditions which result are extremely hard to correct. Briefly, during the severe weather of the northern winter, the moisture in the ground freezes to a depth of from a few inches to a number of feet. Even though the moisture content in the soil is not very high, it is usually sufficient to convert the frozen stratum into a solid mass through which no water can percolate. Indeed, even if the mass is not impervious, no water can pass through it, for its temperature is so low that any moisture which reaches it will be converted into ice. It is, therefore, a barrier through which no water can pass.

When spring comes, the warmer weather first converts whatever snow and ice there is on the ground into water and then gradually melts the ice which is in the soil itself. The melting of the ice in the frozen ground is a slow process—one which, when the spring opens gradually, may take from two weeks to a month or more. But during all of this period—that it, as long as there is any of this frozen stratum left under the surface of the ground—none of the water which is formed by melting the snow and ice which lay on the ground when the thaw began, and none of the rain which falls while this frozen stratum persists, can penetrate the ground farther than the top of whatever remains of the frozen stratum. Thus, if the ground was originally frozen 3 ft. thick and 6 in. of this distance has melted, any moisture which melts on the surface or which falls as rain and is absorbed by the soil must be retained in this 6 in. of melted soil, for it can not, in the nature of things, percolate into the 2½ ft. of ground which is still frozen.

This condition is not so hard to handle on rolling ground for here the surface run-off is high, but on flat ground the results of this condition are apt to prove serous, for here the run-off is slower; indeed, there is apt to be an accumulation of water from surrounding high ground, and when this water has been absorbed in the thin layer of thawed-out ground complete saturation often results. In this way a condition is created which is exactly similar to that which would result if the water table were raised to the surface of the ground. Of course, the strength of any subgrade which is subjected to such a condition is adversely affected by it, and when the pavement is laid so that the top of the subgrade is only a few inches above the surrounding ground or even, as too often happens, a little below the surrounding ground, the complete saturation of the subgrade immediately under the pavement naturally results.

There is nothing strange or unusual about this phenomenon unless it be the amount of water which is sometimes found in the top layers of the ground during these periods. As throwing some light on this, some samples taken from rather porous ground last spring showed:

Top inch, 29.3 per cent of water, by weight.

Top of frozen ground 6 in. below surface, 24.9 per cent of water.

Ten inches below surface (4 in. below frost line), 14.7 per cent of water.

The ground had frozen after rather a wet period and so the moisture content of the frozen ground was higher than would be normal. The other percentages are, however, quite normal for light soil, and while the water content in the first inch is very high this merely serves to show what commonly results at this time of the year. It is needless to remark that soil as wet as this can not support any heavy loads; indeed, a man walking over it sinks into it 2 or 3 ins., so that it is not strange that pavements fail during the period when the frost is coming out of the ground.

Tile drainage does not help this condition. It should be clear that tile drainage can do nothing for such a condition as this, for the essence of the trouble is that the normal percolation of surface water into the lower strata is cut off by the sheet of frozen soil which underlies the surface. As all tile drainage is located some feet below the surface, any sheet of frozen ground so entirely cuts it off that it can have no effect in removing the water on the surface.

Surface Ditches Help.—On the other hand, a good system of surface ditches is an assistance during spring thaws. Such a system usually does not, however, meet the conditions as well as could be desired, for it requires a great deal of attention to keep surface ditches free from obstructions, especially ice, and as a result it is not at all uncommon to find ditches, which in ordinary weather are entirely adequate, standing full of water during spring thaws because ice dams have formed in all of the shaded sections of them.

Another factor of no little importance at this period is the tendency of the least depression to catch and hold water. This is not only because of the saturated condition of the soil as above described, but is also due to the fact that when the air is only slightly above the freezing point, as is its normal condition in the early spring, a relatively small amount of water can be taken up and carried away in the air. There is, then, at this time of the year, a combination of conditions—the absence of normal subdrainage, the clogging of surface drainage, and the low moisture absorbing power of air which all tend to keep subgrades in a wet and weakened state. At least two of these conditions are of such a nature that they must be recognized as phenomena over which there is no control. Even the third, the formation of ice dams in shaded sections of the drainage ditches, is one which is extremely difficult to deal with, but which must be handled if any relief from this condition is to be secured.

There is much which can be said as to the proper functions of drainage systems in the protection of subgrades, but the salient features of good ditch design are matters which are too well known to deserve much comment in this connection. One point, however, deserves mention, and that is that ditches should always be kept open and evenly graded so that they will not impound water. Water impounded in ditches works under the pavement easily and rather rapidly. Running water in highway ditches is to be condemned for the same reason. Where the subgrade is sandy and porous the seepage from water impounded in a ditch or running in a ditch does not spread out very far laterally, but where the soil is heavy the lateral seepage is more of a factor, and, in fact, a good many pavement failures can be traced to these very causes.

Tests of Soils for Subgrade.—Looked at from a little different angle, the important point in this discussion would seem to be that, as there is no justification for the common assumption that drainage will keep a highway subgrade dry, it is neither logical nor correct to design pavements on the theory that their subgrades will be dry. On the other hand, there being every reason to assume that there will be times when very little subgrade in an entirely satisfactory condition and that, in any locality, subgrades of some materials will almost never be as strong as they should be, it would be far more advisable to accept as normal bearing powers a good deal lower than the maximum attained during dry weather, and to discard as unfit for use in the subgrade materials which are known to fall below this limit of strength whenever capillary attraction fills their pores with water. This would imply an examination of the strength of compacted soils containing a relatively high water content, and accepting as inevitable the high water content of soils which is known to be common during the spring months. This would also, as suggested above, imply wasting soils which fell below the established standard of supporting strength under the conditions as to moisture which are normal at this time of the year.

At first glance this may seem to be a visionary scheme, but on careful study it will usually be found that the amount of testing, which would be required in order to eliminate undesirable soils, would be no greater and no more expensive than the testing now done by every well-managed highway department in order to insure the satisfactory nature of other building materials. As there can not be the slightest doubt that the heavy loadings now carried on the highways makes it as important that the subgrade should be composed of materials of proper characteristic as it is that the base should contain good cement or the top good brick, an equal amount of care in the selection of materials for the subgrade would seem to be in line with the general progress which is being made in the art of highway construction.

Results of Impact Tests for Determining Wear of Concrete Aggregates

Results of tests made in the laboratory of the New York State Highway Department to determine the wear resisting values of various aggregates used in concrete roads were summarized by Mr. H. Eltinge Breed, Consulting Engineer, New York City, in a paper presented May 22 at the Canadian Good Roads Congress. The tests were made with a machine which generates impact stresses closely paralleling those cut up by traffic. This machine was designed in the laboratory and has been in service for the past two years.

In general the machine consists of an arm which is raised by a cam and falls freely, striking the concrete cube. At the head of the arm are placed nine hitting points, armored with non-slip horse calks, each point and its shaft being held in place by a spring giving ½-in. play to compensate for any irregularity or unequal wear during test in the surface of the sample. The effective weight of the head is 29 lb., and the blows are delivered at the rate of 100 per minute. The sample used is a 6-in. cube or cylinder placed upon a table which is revolved by a dog attachment, so that the blows of the calks strike in nine concentric circles, ¼ in. apart. To date several hundred tests have been run with this machine, of which the following results are representive:

Coarse aggregate.	Fine aggregate.	Mix.	No. tests.	Grams loss per test.	Average loss.	Remarks.
Trap	Sand Niagara	1:1½:3	3	150-110	103	Small stone
				105-95		area omitted.
Trap	Sand Cowbay	1:1½:3	4	110-120		
				110-100	110	
Trap	Sand Albany	1:1½:3	4	140-100		
				125-125	122	
Trap	Sand Long Island	1:1½:3	2	120-135	127	
Trap	Sand Marlboro	1:1½:3	2	130-135	132	
Trap	Tailings-graphite	1:1½:3	2	155-135	145	
Trap	Sand-Boonville	1:1½:3	4	165-130		Group (1)
				165-135	149	103-165
Trap	Tailings iron ore	1:1½:3	5	200-155		
				165-155	164	Excess grout
				165-180		omitted.
Trap	Sand Cowbay	1:2:4	2	150-150	150	Group (2)
Trap	Sand Albany	1:2:4	3	180-160		Small stone
				185-225	175	area omitted
Trap	Sand Marlboro	1:2:4	2	180-170	175	
Syenite	Sand-Booneville	1:1½:3	8	150-145		
				150-140	141	Group (3)
				145-125		Small stone
				185-130		area omitted.
						141-186
Syenite	Sand-Booneville	1:2:4	4	180-205		
				180-180	186	
Buffalo Limestone	Sand Niagara	1:1½:3	5	150-120		
				155-125		Group (4)
				135	137	137-170
Limestone	Sd. Cattaraugus	1:1½:3	5	155-160		
				140-125		
				160-200	148	Excess grout
						omitted.

The above results indicate that generally the average loss increases as the mortar strength of the sand decreases. An average loss for each test shows that there is greater strength in the 1 : 1 ½ : 3 mix than in the 1 : 2 : 4 mix. It is interesting to note that syenite with the French coefficient of 12.5 shows approximately an equal loss under this test to Buffalo limestone with a French coefficient of 7.9. On the basis of the Deval test, the limestone is inferior for road purposes to the syenite, but service conditions indicate that the Buffalo limestone and many other limestones with a French coefficient of 7 and better, are very satisfactory in service.

In general six conclusions from the full results of the impact tests seem justifiable:

(1)—Crushed stone concrete resists impact better than gravel concrete.

(2)—Large sized material is more durable than the small sizes.

(3)—Toughness is a very important factor in aggregate that is subjected to impact.

(4)—The fine and coarse aggregate must both be good, if we are to get the most from the pavement.

(5)—Coarse-grained sand mortar resists impact better than a mortar made with finer grained sand.

(6)—No relation has as yet been observed between compressive strength and resistance to impact.

Practical Hints for the Road Foreman*

By ALEXANDER FRASER,
Assistant Chief Engineer, Department of Highways, Province of Que.

The problem of improving a highway can be divided into two distinct parts, each differing considerably from the other: First, preparing the plan; second, carrying out the work.

Although these two parts of the problem cannot be studied independently on account of their reciprocal relations, their respective solution may, nevertheless, be confided in a direct manner to persons with different qualifications.

It is the engineer to whom is generally given the task of preparing the plan. It is he who generally makes the first inspection and preliminary survey, examines the course, studies the nature of the soil and drainage conditions and the means of improving them if need be, improves the alignments and the grades, finds and examines carefully all available material which may be used with economy in that locality or outside of it, and inquires as to present traffic conditions and provides for the future in this connection while also keeping in mind the present value and the probable development of municipalities served by the road.

The foreman who has direct and permanent control of the work plays a very important part in the economical execution of the work. This complete control must be exercised in two distinct ways: The organization of the job and the quality of the work.

The organization of the job includes a wise disposition and equitable control of labor and a rational disposition and use of the plant and tools. This question of labor is one which requires a large amount of attention, the more so in these times of economic disturbance, as the demands of labor are most distressing problems for both industry and the government. The workman not only demands better daily remuneration for his work, but also insists that the length of the working day be considerably diminished.

However, as against this, the first cost of the materials for road construction has only slightly increased; for example, stone from efficient quarries commands today approximately the same price as in 1916; the same thing applies to gravel, sand the bituminous material. Cement, however, has reached a much higher price, its cost having increased approximately 40 per cent.

Bearing in mind this increase in the cost of labor, it is more than ever important to obtain from our labor the maximum efficiency through a more rational distribution of the men on the work, and by more efficient methods of doing the work, at the same time carrying out as far as rationally possible the use of tools and machines to diminish labor costs.

To arrive at this goal it is necessary to see that each gang is composed of exactly the number of men necessary for the work planned. For example, it is obviously irrational to place six men at spreading stone when four or even two would be sufficient. It is also necessary to see that there shall not be four carts drawing stone to the crusher when three or two would be amply sufficient.

The efforts of a good foreman must tend towards obtaining the maximum amount of work with the least possible labor. He should see that the crusher bin is always well filled. On a water-bound or bituminous macadam job, carried out with local stone, the capacity of the crusher will be the keynote of the whole organization. This capacity will rule the number of men and the number of wagons. It is, however, obviously necessary to keep the crushers to maximum capacity at all times. If a crusher has a capacity of 80 tons of stone a day, every effort must be made to obtain these 80 tons each and every day. The foreman must not be satisfied with any one day in which this maximum has not been obtained. Should any defect in the engine or the crusher make it difficult or impossible to obtain the maximum output, it is more economical to stop the crusher at once and make the necessary repairs. A crusher with a daily capacity of 80 tons requires two wagons and drivers, four men to help the drivers to load stone, and three good men feeding stone to the crusher.

If the crushed stone is to be transported a mile from the crusher, there will be needed four good teams with dump wagons of at least 1½ yds. capacity, to keep the crusher going. I am supposing that the road is approximately level. Three men will be sufficient to spread the stone.

On a concrete job the capacity of the mixer will be the keystone of the organization. It will be necessary to see to it that the preparation of the sub-grade and the supply of material shall be such that the mixer will never be idle and run at all times to its full capacity. Have just the right number of men and no more to feed the mixer. The same rule will apply to the construction of a road to be built of bituminous concrete. The capacity of the plant for drying the stone and heating and mixing the bitumen will determine the number of men in each gang in such a way as to obtain the maximum output from the plant.

In the construction of a gravel road, the rules are not quite so well laid down. Everything will depend generally on the number of teams and men which can be obtained in the municipality. Given a certain number of teams to transport gravel and the distance the material must be transported, one need only put on the road the exact number of men necessary to spread the gravel which this number of wagons can transport, and in the pit just the number of men necessary to load the wagons.

For example, if the pit is 1½ miles from the job to be gravelled, using 12 2-horse wagons, carrying 1¾ yd. per load, each wagon should make six trips a day, amounting in all to 60 trips, or a total of 105 cu. yd. To spread this quantity of gravel in proper shape should not take more than five men. Any other men available can be used to clean or dig ditches, prepare subgrade, etc.

In special work, such as bridges, culverts, walls and drains, if it is necessary to use craftsmen such as carpenters, masons, etc., two things must be borne in mind: First, to use only the exact number required; next, economize as much as possible on this expert labor by letting these men do only work requiring such training and knowledge. In building concrete bridges do not let the carpenters, who are building forms, do any work outside of this. I mean, do not let them carry planks or saw or nail them. In other words, do not let them do a number of jobs which can be done just as well and more cheaply by unskilled labor.

The choice of tools and plant well adapted to the job has also a great deal to do with the efficiency of the work. It is not possible to give a complete list of work which is done by hand on a construction job, but this can be considerably reduced by a judicious use of plant and machinery. The essential part is that the machines shall be carefully chosen.

There are three classes of work in which large sums of money are uselessly spent by the lack of adoption of up-to-date methods. The first includes all excavation work. There are on the market a number of machines for all classes of excavation, both in rock and in earth. Among these are some which are designed for large work and which can be economically employed on small jobs, but there are others with a capacity of not over 4 to 10 cu. yd. per hour which can be very economically used to replace pick and shovel work.

In rock work it is often advantageous to use small mechanical drills instead of hand drills. For drying and unwatering an excavation, use gasoline or electric pumps wherever possible instead of hand pumps. The second class of work under this heading comes in the mixing of concrete For small jobs there are on the market a number of very good small mixers run by gasoline engines. These mixers can be economically used even where the consumption of concrete is only a few yards per day and can also be used on large work as an auxiliary to the larger mixers.

The third kind of work where manual labor is usually used, is the transportation and placing of construction materials. Cars and scows are loaded and unloaded by hand; wagons are also usually loaded by hand, although nowadays most of the wagons dump automatically. For all these things there are machines to do the work that will save sums proportionate to the quantity of materials to be moved. It is true that machines cannot always be used, but my point is that they should be used whenever at all possible and even on the simplest jobs the work can be so planned as to reduce to the lowest possible amount the manual labor expended.

Road construction requires a great deal of shovel work. Much can be said on the kind of shovels which should be supplied to the men, varying with the kind of work; the horizontal and vertical distances through which the shovel must handle the materials, etc. This study would take up too much space. It is very true, however, that very few laborers understand the correct use of a shovel. It is astonishing how very few men have ever been shown the proper handling of their tools; it has been demonstrated that a man using a shovel correctly can handle easily three more shovelfuls per minute than the man using an incorrect method of handling the shovel. We know that a man loading a wheelbarrow or a cart can handle approximately 15 shovelfuls a minute. The incorrect method of shoveling, resulting in a loss of three shovelfuls per minute, means a net loss of 20 per cent, with just as much energy expended by the workman.

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*From a paper read May 21, 1919, at the Canadian Good Roads Congress

Tractor Truck Designed Especially for Traveling Over Rough Ground

A tractor truck designed for hauling over unimproved roads and fields is illustrated below. While it is a road-going machine, its particular value lies in its ability to travel even in places that are practically impassable for a wagon drawn by horses.

In order to secure sufficient flexibility under different operating conditions the transmission is provided with four speeds forward and one reverse. On low gear the truck has a speed of 1¾ miles per hour, on second speed 3½ miles per hour, on third, or direct, 6 miles per hour and on fourth, which is an over-speed, 8 miles per hour. The reverse speed is 1½ miles per hour.

This truck was especially designed to travel over rough roads and a 3-point frame suspension has, therefore, been provided, and, as a still further safe-guard, on account of the extreme conditions under which the truck must operate, the motor is mounted on three points. With the exception of the front and rear axles and wheels the entire chassis is spring suspended and the heavy tubular radiator is again spring suspended on the frame. The track wheels pivot on the axles as a center and either may move about its center independently of the other. The rear axle is kept in correct alignment with the frame through radius rods with ball and socket at the front end, and a universal block at the rear.

B-6, 120-H.P. Tractor Truck Employed by Du Pont Engineering Co. in constructing Government T. N. T. Plant at Ives.

In this tractor truck, the useful load carried adds to the tractive power of the vehicle, and it has, therefore, been found desirable to make the truck of high grade material in order to reduce the weight as much as possible. Special attention in the design has been given to the protection of all lubricated surfaces. The transmission is of the totally enclosed type; the universal joints, of the ring and pin type, are enclosed to keep out dust and retain grease; the rear axle is of the full floating type, totally enclosed, and the double gear reduction in the track wheel is also totally enclosed and ample provision made for lubrication. The pins which connect the articulating treads of the track wheel are hollow bored and filled with grease, which tends to keep dust and gritty material out of the joints of the tread.

The 6 cylinder, 5¾ in. by 7 in. motor is provided with a double system of ignition, consisting of a high tension magneto and storage battery and dstributor, each system having its independent set of spark plugs. A two unit system of starting and lighting is provided, the motor being geared directly to fly wheel through a Bendix automatic transmission. As the motor is too large to be cranked directly by hand a geared reduction is furnished with the hand crank, which can be used in an emergency.

Where trailers are used, the conditions may be such that there are a few short difficult grades so steep that the truck has not sufficient power to climb them with all trailers attached. For such a condition, a power driven winch can be furnished, if desired. Provision is made in the transmission that the winch may be driven in either direction, regardless of the direction in which the truck is traveling. Where a hydraulic hoist is used the pump can be driven directly from the transmission, whether the truck is standing still, or traveling in either direction. The gears for both the winch and the hydraulic pump are totally enclosed within the transmission.

One of the novel features of this truck is the two speed steering gear. Since the truck was designed to travel over roads at a speed of 8 miles per hour, the gear ratio between the hand wheel and front wheel must be such as to be quickly responsive. Such a ratio, however, on a heavy vehicle of this type makes it impossible to turn the wheels on very soft roads, or plowed fields, and provision is made for interposing a gear reduction between the hand wheel and the shaft of the steering gear, which is of the worm and sector type. The truck is ordinarily handled and steered in the same manner as an automobile, and, not by declutching one side or the other. A differential is provided equalizing the power applied, and relieving the mechanism of stresses caused by one track wheel having to travel a greater distance than the other when going over uneven ground.

This tractor truck is manufactured by the Allis-Chalmers Mfg. Co., Milwaukee, Wis. The design is the result of 4 years experimenting.

Street Cleaning at Los Angeles With Vacuum Cleaners

The use of vacuum cleaners has practically eliminated flushing of paved streets in Los Angeles, Cal., according to the last annual report of A. C. Hansen, City Engineer, which gives the following particulars of this method of street cleaning: During the year ending June 30, 1918, four vacuum cleaning machines were employed, working two shifts of 8 hours each under the supervision of two city inspectors. The city paid 10½ ct. per 1,000 sq. yd. cleaned, the contractor furnishing and maintaining the equipment with a driver. The four machines clean approximately 1,500,000 sq. yd. of pavement each day of two shifts. These machines have a vacuum suction apparatus, with a rotary fan operated by an independent motor mounted on a 2½-3½-ton truck. Each machine is equipped with a speed recordograf that registers the speed traveled during any portion of the day, the distance traveled, and the time during which no work is being done, whether standing in the garage or on the shift. As the speed at which these machines are operated is an important factor in the quality of work produced, the contract is conditioned for a speed not to exceed 4½ miles per hour, and as the recordografs register the miles traveled during each shift they operate (within certain limits) as a check upon the speed maintained while cleaning a street, and on the area claimed to have been swept. Each machine is given a certain group of streets for each shift during the week. No machine is allowed to work on streets not on the particular route to which it is assigned except by authority of the city foreman in charge of the work. Within certain limits these routes are sufficiently flexible to meet the unforeseen change in conditions that may arise.

May Sets New Record in Road Work.—During May the Secretary of Agriculture approved project statements for 124 Federal aid projects, involving the improvement of 750.87 miles of road at a total estimated cost of $15,120,771., and on which Federal aid in the amount of $6,382,081 was requested. This represents the largest number of project statements approved during any month since the passage of the Federal Aid Road Act. During the month there were executed by the Secretary and the several state highway departments 81 project agreements, involving the improvement of 667.71 miles of road at a total estimated cost of $7,992,867, and on which $3,570,087 Federal aid was requested and set aside in the Treasury. In addition, agreements to cover 59 other projects were placed in process of execution during the month. Up to and including May 31, 1919, project statements for 1,188 projects had been approved. The 1,188 projects involve 11,350.10 miles of road, a total estimated cost of $108,295,329, and a total of $43,076,176 Federal aid. On the same date 617 project agreements had been executed, involving 5,291.86 miles of road, at a total estimated cost of $47,426,749, of which $19,521,259 was Federal funds.

Operations of Municipal Asphalt Plant of Los Angeles

Paving material amounting to 1,403,910 cu. ft. was produced by the municipal asphalt plant of Los Angeles in the 4-year period beginning April, 1915. The totals and average costs for this period, according to the last annual report of A. C. Hansen, City Engineer, were as follows:

	Cu. ft.	Average cost per cu ft. ct.
Standard surface mixture	1,251,080	14.59
Bitulithic	39,490	13.71
Binder mixture	59,670	10.97
Warrenite mixture	37,720	14.00
Topeka mixture	700	15.00
Special mixture	15,250	11.84

The plant which has been in operation since April, 1915, was designed and built by the Engineering Department. The plant orginally cost $8,354. Since the original construction there has been expended $20,270 in additions and enlargements, making a total cost to June 30, 1918, of $28,625 for plant and equipment. Of this amount $4,535 has been charged off as depreciation, giving a present (June 30, 1918) depreciated value of $24,090. This additional plant outlay is the cost of construction of the additions and enlargements below indicated: From Feb. 16 to April 6, 1917, the plant was closed for alterations. Two additional rolls were installed, increasing the capacity of the plant from four rolls, with an estimated daily capacity of 2,400 cu. ft., to six rolls, with an estimated daily capacity of 3,400 cu. ft. One additional mixer was installed, giving the present plant two mixers of 1,000 lb. capacity each, for each batch. A dust bin, elevator, and feed and dust exhauster were built which will give a more uniform mixture with a decreased cost for operating labor. During the fall of 1916 a two compartment concrete storage and heating tank was built, with a capacity of 390 lb. of asphalt. During the spring of 1918 a number of minor additions were made.

During the fiscal year ending June 30, 1918, the following tabulated quantities of paving material have been produced at the unit cost indicated.

	Quantity of mixture produced year 1917-8, cu. ft.	Increase (+) or decrease (—) compared with year 1916-17, cu. ft.	Cost per cu. ft. year 1917-18 ct.	Increase (+) or decrease (—) compared with year 1916-17, ct.
Standard surface mixture	547,550	+237,690	15.88	+2.48
Bitulithic mixture	23,920	+ 9,610	14.39	+2.64
Binder mixture	24,970	+ 10,010	13.03	+1.85
Warrenite mixture	37,720	+ 37,720	14.00	......
Topeka mixture	700	+ 700	15.00	......
Special mixture	000,000	— 13,270	.....	......
Total and net	634,860	+282,460	.....	......
Average	......	....	15.60	+2.45

The increased cost per cubic foot of mixture produced during the past fiscal year is due to the increased cost for labor and material during this year over past years. During the year ending June 30, 1918, the daily rate of labor has been increased 10 per cent, while the cost of asphaltic cement increased more than 50 per cent. The unit costs above given include depreciation of and interest on plant and equipment and 7½ per cent overhead administration.

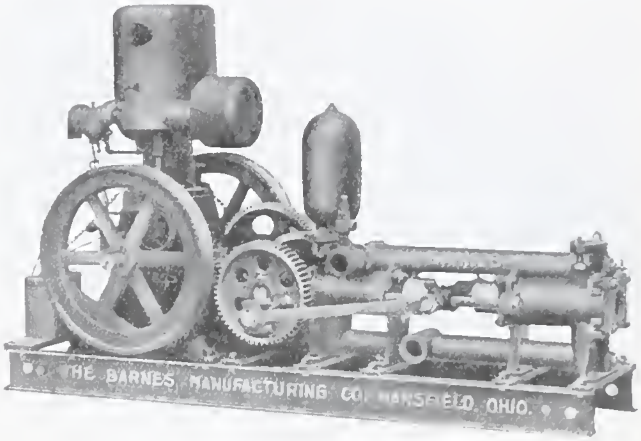
During the past year the plant has been operated 271 days, at an average output of 2,343 cu. ft. per day, or 69 per cent of the estimated plant capacity. The maximum output was 3830 cu. ft. on July 30, 1918, while the minimum output was 250 cu. ft. on Nov. 23, 1917. During the fiscal year 1914-15 (3 months only), 1915-16, and 1916-17 the output was respectively 40 per cent, 50 per cent and 61 per cent of the plant capacity.

The operating force at the asphalt plant was as follows:

1 fireman.
1 asphalt helper.
1 mechanic.
2 laborers at $3.
10 laborers at $2.75.
6 sand haulers.

Pump Especially Designed for Road Work

"An Old Principle Applied in a New Manner" briefly but adequately describes the pump, especially designed for road building, which has just been placed on the market by the Barnes Manufacturing Co., Mansfield, O. Believing that the outside packed plunger displacement type of pump was the most practical for road construction, the Barnes Co. engineers have endeavored to develop a pump of this type consisting of a minimum of parts thereby giving extreme simplicity, affording rigid construction and lessening the liability for repairs and reducing the weight from 25 to 50 per cent. The double acting, single cylinder, brass lined, leather packed piston pump has been largely used on road work because of its lightness and portability. The new Barnes pump retains these features, adds increased accessibility and besides replaces the brass lining and leather packed piston with the outside packed plunger, which permits of the pump being maintained at constant efficiency (capacity) by simply tightening the glands. When the packing around each plunger is worn out, as shown by the fact that the gland has been tightened as far as possible, it is stated to be but a matter of 15 minutes to remove the glands, repack the plungers and replace the glands. As the pump is of the displacement plunger type, no brass lining is needed in the cylinders and drawing sand into the pump will not injure it, although precautions should be taken to pump clear water only. The valves of the pump are of the wing type, with bevel seats, both of solid bronze. The valves are immediately accessible, as well as the interior of the cylinders, after unbolting their respective valve port caps and cylinder heads. The working parts of the pump coming under an alternating load, such as the crossarm (head) and connecting rods are of cast steel and malleable iron, respectively, giving great strength where needed and insurance against sudden breakage. The gears and pinions are machine cut, the latter of steel. The design of the pump permits of mounting the power end to end with the pump on channel steel skids, giving a light and strong form of base, thereby increasing the portability of the outfit. It is also noticeable that the pump is close to the ground—a very desirable feature for portable work.



New Pump for Road Building Outfits.

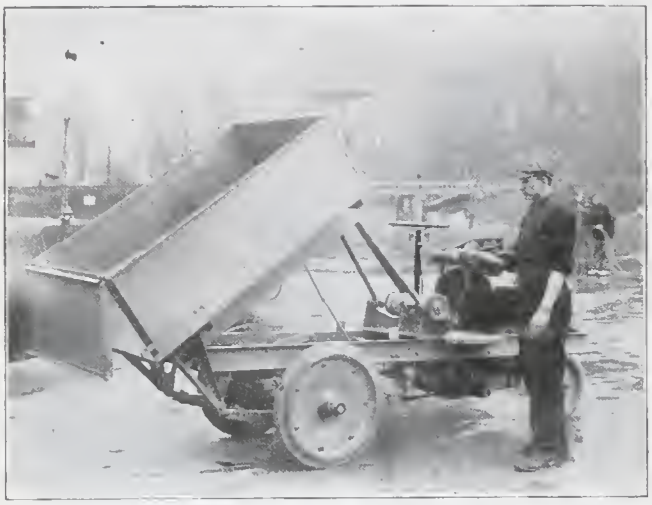
Cost of Street Cleaning at Cincinnati, O.—Comparative unit costs for the principal street cleaning functions at Cincinnati, O., for a 4-year period are given in the last annual report of Fred Maag, Superintendent of Street Cleaning. The table follows:

	1915		1916		1917		1918	
	Unit cost.	Unit cost with overhead.	Unit cost.	Unit cost with overhead.	Unit cost.	Unit cost with overhead.	Unit cost.	Unit cost with overhead.
Flushing, per square	$0.137	.277	.119	.241	.121	.268	.120	.274
Street sweeping, per cu yd.	.242	.434	.270	.476	.286	.526	.332	.633
Ash collection, per cu. yd.	.277	.465	.282	.468	.299	.515	.344	.613
White wings, per 1,000 sq. yd.	.272	.312	.305	.252	.301	.247	.313	.360
Broom gang, per square	.268	.324	.243	.295	.238	.282	.264	.305
Cleaning gutters, per square	.132	.147	.136	.153	.144	.162	.138	.155
Cleaning gutters after flushing, per square	.148	.164	.136	.151	.140	.157	.167	.187

Square = 16,000 sq. ft., or 400 lin. ft.

A Three Wheel Tractor That Has Many Uses

A dual machine that does the work of both a truck and tractor has been placed on the market by the Clark Tructractor Co., 80 E. Jackson boulevard, Chicago. Because of its special design and patented features it is claimed to be particularly useful for charging concrete mixers, hauling sand, cement, crushed stone, etc. On account of its design it can climb narrow, steep inclines, run in and out of buildings and tight places and turn in its own length. This tructractor is equipped with two single piece metal disc wheels in front and one in the rear. As a truck it carries a 1½ ton load and as a tractor it will haul several trailers. The weight of machine complete with standard body is 2050 lb. It is equipped with a four-cylinder, 3⅛ by 4½-in. engine and an internal-gear-driven front axle. The wheelbase is 72 in. with a tread of 35½ in. The over-all length is 112 in. with an over-all width of 42 in. The height of the platform is 28 in. above the ground. The ground clearance is 9½ in. A speed of 1 to 15 miles per hour is obtained with a gasoline consumption of 3 gal. per day.



Clark Tructractor.

Industrial Notes

The C-A Wood Preserver Co., Inc., St. Louis, Mo., has been conducting an educational campaign to impress upon this year's graduates of engineering colleges the importance of making some attempt to preserve all timbers which are exposed to rot or decay. The information furnished the students consisted of a series of questions and answers giving useful data on wood preservation.

The Barber Asphalt Paving Co., Philadelphia, has announced that following the promotion of Charles W. Bayliss, formerly manager of the street and road department, to vice president in charge of sales, the following changes in organization became effective June 1, 1919: J. E. Morris, manager, street and road department, Philadelphia, Pa. H. M. Stafford will succeed Mr. J. E. Morris, as assistant manager, in charge of the eastern district, with headquarters at Philadelphia. F. F. Massey is promoted to succeed Mr. Stafford, as assistant manager, in charge of the southwestern district, with headquarters at Memphis, Tenn. G. R. March is promoted to succeed Mr. T. H. Morris, as sales manager of the Iroquois department.

The Acme Motor Truck Co., Cadillac, Mich., builders of the Acme line of worm drive trucks, consisting of 1, 2, 3½ and 5-ton models, have announced a price increase effective July 1 of $100 each for the Model C 3½-ton and the Model E 5-ton trucks. The 3½-ton truck of improved design is now in production. This truck is equipped with a pressed steel heat-treated frame instead of a channel section. It is equipped with a Continental E 7 motor with flywheel inclosed. These improvements, with others, are accountable for the increase in list of $100 on this model. The Acme 5-ton chassis Model E has been reported on an actual cost basis, this being practically the first year of production on this model, the price quotation heretofore having been nominal.

T. H. Morris, for the past 10 years associated with the Iroquois Department of Barber-Asphalt Paving Co., as manager of its Chicago district and also sales manager, with headquarters at the general offices in Philadelphia, and J. J. Staley, eastern representative of the above company, have resigned and formed the firm of Staley & Morris, engineers, with offices at 2009 Market St., Philadelphia. In addition to conducting a general engineering practice, specializing in contractors' plant installations, they represent the following firms exclusively in the Philadelphia district: F. D. Cummer & Son Co., Littleford Bros., Edward F. Terry Manufacturing Co. They are also promoting the sale of Lidgerwood hoisting engines and Sauerman Bros. dragline cableway excavators and power scrapers, in addition to a complete line of construction machinery and contractors' plant equipment.

C. R. Messinger, vice president of Chain Belt Co., Milwaukee, who recently returned from a three months' investigation of business conditions in Europe, believes that the United States will get the big bulk of European trade after business conditions become more normal. "At present European business is marking time and the general feeling seems to be that even the signing of the peace terms will not bring about any great change immediately. When things do open up, however, American manufacturers will be found in better shape than their European competitors and should get the bulk of the business, though liberal credit terms will be necessary." C. L. Pfeifer, treasurer of the same company, has just returned from a several weeks' stay in Cuba, where he arranged for extending the company's representation and studied business conditions generally. According to Mr. Pfeifer, Cuban business is in a very prosperous condition, with indications that this will continue for perhaps three years. The country has just broken all records in its sugar crops and planters feel that the succeeding crops will be still greater.

Personals

F. W. Simonds has resigned as city engineer of Rahway, N. J.

R. J. Windrow has been appointed state highway engineer of Texas.

Roy C. Bailey, for the past 9 years county road commissioner of Shiawassee County, Michigan, has resigned.

H. Walker Powell and J. Davis Powell have organized the Powell Paving & Contract Co., of Columbia, S. C.

Clyde Walters, of Byers, Colo., has been appointed field engineer of the State Highway Department of Colorado.

A. R. Montgomery, Jr., W. S. Gearhart and W. B. Kester have organized the Middle States Construction Co. of Peoria, Ill.

George A. Duren, formerly state highway engineer of Texas, has been appointed road engineer of Harrison County, Texas.

A. S. McFadden has resigned as assistant engineer of the Kansas State Highway Department and has become associated with the Kansas Engineering Co., Topeka, Kan.

Walter G. Kirkpatrick, city engineer of Birmingham, Ala., has been appointed consulting engineer of Monroe, La., for a 4-year term. He will serve in an advisory capacity to all city departments.

William Steinberger, of Pt. Pleasant, formerly a division engineer with the state road commission of West Virginia, has been appointed county road engineer for Doddridge County, West Virginia.

H. A. Marshall, acting road engineer of the Kansas State Highway Department, and O. J. Eidmann, assistant bridge engineer, have resigned and have become connected with the Southwestern Engineering Co., Hutchinson, Kan.

M. W. Watson has been appointed state highway engineer of Kansas to fill the vacancy caused by the resignation of W. S. Gearhart. Mr. Watson has been acting in the capacity of state highway engineer since July 15, 1918, when Mr. Gearhart resigned to enter the army. Mr. Watson is a graduate civil engineer of the Ohio University. He has practiced engineering in connection with coal mining, railroad work and municipal work in Southeastern Ohio, has served in a civilian branch of the United States Army Engineers in connection with the improvement of the Ohio River. Previous to entering the service of the Kansas Highway Commission, Mr. Watson served for five years with the Illinois State Highway Department, from which employment he resigned to accept the position of road engineer with the Kansas Highway Commission, when it was created in the spring of 1917. He served in the position of road engineer from 1917 until his appointment of acting state highway engineer.

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Waterworks and Hydraulics Monthly Issue

ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials

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Volume LII. CHICAGO, ILL., JULY 9, 1919. Number 2.

The Art of Quickly Acquiring Long Experience

Lack of sufficient experience prevents young men from securing positions of great responsibility. Most young engineers resign themselves to this seemingly unavoidable condition, placidly waiting for time to remove the handicap of meager experience. Yet this attitude toward experience is not wise, as may be seen by analyzing the reasons why experience is valuable to its possessor.

Experience may be defined as knowledge and skill acquired by observation and practice. While skill is always personal, knowledge may be imparted to others. Hence there is but one kind of experience that can not be acquired by reading, namely, the skill that results from practice. Most men fail to recognize this distinction and speak of all experience as if it were a thing to be obtained by each individual only through his own acts of experiencing.

Since the knowledge part of experience (as distinct from the skill part) may be learned by reading and thinking, it is feasible for any man to acquire a vast deal of that sort of experience in a comparatively short time by systematically studying. It is true that knowledge thus gained is less vividly impressed on the mind than knowledge secured by personal observation. But this psychological difficulty can be overcome by proper effort. Since the object should be to produce a deeply engraved record in the brain, the man who seeks to make the experiences of other men as useful as his own should systematically school himself in the following manner:

First, read with an object, confining most of the reading for a given period to subjects that will serve to attain that object.

Second, analyze and compare the facts thus found, noting particularly all quantitative facts.

Third, review the salient facts again and again, thus impressing them on the mind. In this way the lack of vividness of personal experience is compensated by repetition of the facts.

Fourth, search for old records of desired facts, the older the better. It is far more impressive to read Agassiz's account of how he came to formulate "the theory of the glacial epoch" than it is to read the bare theory in modern books on geology. So, too, the story of how an English county surveyor, William Smith, originated the theory of geological epochs, and came to be called "Strata Smith," is much more impressive than Smith's theory itself, as we find it in geologies.

Go back in the realms of science to the discoverer or inventor himself if you wish to share his original thrill of triumph. The average author of scientific books is a "dub" when it comes to thrilling you. He gives you bare results, as a rule, without

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

the personal struggle and the original reasoning that yielded those results. For this reason the original articles in magazines and society transactions are usually far more valuable than the rewritten stuff derived from them and printed in the latest text books. If you want to absorb the experiences of other men, go to the writings of those very men, and live again their experiences as nearly as may be.

"The World's Best Books," by Parsons, contains some good advice about books and about reading; but its author makes a serious mistake in saying that only the latest scientific books need be read, since they include the best of all that has been written previously. One who has written a scientific book himself would not claim any such completeness for it. But we go farther and assert that even were a scientific book to contain the "substance" of all that had been printed before on the subject, it would lack the "spirit" that lives in the original authorities. It is this "spirit" that arouses your interest to the highest degree. It is the intensity of your interest that mainly determines your ability to remember what you read. It is the facts that you remember that constitute the knowledge that is instantly available in forming judgments. And it is the soundness of your judgments that is the best test of the extent of your worth while experience.

How Many Meters Should a Man Read Daily?

The number of units of work that a good workman can perform daily under given conditions should be known by his manager. How many water meters should be read per 8-hour day by a fairly good reader? Judging from a recent tabulation given in the Municipal Journal, there is a wide range of effectiveness of meter readers, even where conditions seem to warrant no such variation. Thus in Los Angeles, with 100,000 "outside" meters, 50 per hour is said to be the average; whereas in Washington, D. C., with 61,000 "outside" meters, 22 per hour is given as the average. The ratio is almost 2½ to 1. Even greater differences exist in other cities as to the number of "inside" meters read per hour.

The number of meters read per hour obviously depends not only upon the efficiency of the men, but upon other conditions such as: (1) The distance from the office to the place where meter reading begins. (2) The distance apart of meters. (3) Whether the meters are inside or outside the building. (4) Whether the readers walk or ride.

The following are typical examples selected from the above mentioned tabulation:

TABLE I.—CITIES HAVING OUTSIDE METERS.

	Number of meters.	Average number read per man-hour.
Alhambra, Calif.	2,100	29
Los Angeles, Calif.	99,600	50
San Diego, Calif.	15,169	41
Pasadena, Calif.	12,547	38
Whittier, Calif.	1,951	20
Washington, D. C.	61,107	22
Atlanta, Ga.	33,000	30
Augusta, Ga.	7,500	20
Gadsden, Ala.	2,030	60
Lewiston, Ida.	1,200	38
Atlantic City, N. J.	7,398	40
Oklahoma City, Okla	13,000	28
Portland, Ore.	17,588	30
Memphis, Tenn.	19,734	30
Knoxville, Tenn.	13,908	67

Average of these 15 cities, 36.

TABLE II.—CITIES HAVING INSIDE METERS.

	Number of meters.	Average number read per man-hour.
Hartford, Conn.	15,451	12
Middleton, Conn.	2,300	11
Concord, N. H.	2,576	20
Elmira, N. Y.	10,032	18
Syracuse, N. Y.	28,133	20
Solvay, N. Y.	990	*15-†20
Worcester, Mass.	20,715	14
Grand Rapids, Mich.	24,530	8
Duluth, Mich.	12,144	15
Minneapolis, Minn.	60,930	10
Akron, O.	26,000	28
Cincinnati, O.	55,000	20
Dayton, O.	30,138	23
Meadville, Pa.	3,376	31
Wilkinsburg, Pa.	15,686	25

Average of these 15 cities, 18.

*Residence. †Business.

Comparing the averages in these two tables, it would appear that twice as many outside meters can be read daily as inside meters.

At Solvay, N. Y., 15 residence inside meters and 20 inside business meters are averaged per man-hour. This is apparently due to the great distance between residence meters.

These data make it clear that waterworks superintendents can profitably study the reasons why there are such great variations in the daily work done by meter readers.

Why Waterworks Material and Equipment Will Not Recede in Price

The price of iron and steel products is largely based on the price of pig iron. For example the price of cast iron pipe is usually about twice the price of pig iron per ton, and the price of structural steel shapes is usually almost three times the price of pig iron per pound.

John W. Hill, financial editor of the Iron Trade Review, recently said:

"American bankers and economists insist that the dollar has experienced a shrinkage to 50 ct. measured by the prewar standard of value.

"A ton of pig iron is worth now, roughly, $26 at the blast furnace; but measuring the dollar with the prewar yardstick this price is cut in two and we see pig iron, according to normal conditions with an actual value in exchange of only $13 a ton, slightly less than the prewar average. Thus it is clear that sharp price cuts are hardly to be expected in the immediate future and will come about only with the recovery of the value of the dollar which will result from the process of deflation. This is usually a long drawn out operation. In the case of the prices after the civil war it was approximately 12 years before prices reached a normal basis."

The armistice was signed seven months ago, yet price level remains substantially unchanged. In the June 28 issue of Literary Digest a long abstract was given of the opinions of business men, bankers, and editors of daily and trade papers. There was striking unanimity in the belief that the present high price level will persist for a great many years. Also it is noteworthy that the reason most commonly assigned for the persistence of high prices is the slowness with which the world's currency will be depleted. We quote again from Mr. Hill:

"The total world expansion of credits and currency caused by the great war is estimated at $250,000,000,000. With such an excessive supply of purchasing power it is inevitable that the money unit should be cheapened, for money like every other commodity is affected by the law of supply and demand."

Political economists for more than a century have held that doubling the supply of money doubles the prices of commodities, if other conditions remain unchanged. Fifteen of the nations of Europe have tripled their currency during the war by issuing paper money; and the European prices have risen accordingly. America has increased her gold supply 55 per cent, with no prospect of a decrease and a possibility of a further increase. Steel and iron prices in America are about 70 per cent above prewar prices. It is safe to predict that they will recede little if at all during the next few years.

Why and How Water Rates Should Be Increased

"Every tub should stand on its own bottom." This economic maxim holds true whether a plant is owned by a city or by a company. If correctly applied, this maxim results in charging rates for each class of service sufficient not only to pay operating expenses but interest on the plant assignable to each class of service.

The city at large should pay the water department adequately for fire protection, sewer flushing, street sprinkling, and for other general purposes. This is rarely done, but failure to do so may throw an excessive burden on the other water users. Now that it is imperative to increase the income of water departments in most cities, perhaps the easiest way to secure the initial increase is to make a reasonable charge for fire protection and for other public purposes.

Cities that own their electric plants have usually found it popular to charge low rates for domestic lighting and high rates for street lighting. The popularity of this plan has led to many abuses. The Seattle municipal plant, for example, has charged about twice as much per kilowatt hour for street lighting as was charged by the private plant of Portland. To offset this overcharge for street lighting, Seattle has undercharged the domestic consumer.

We do not advocate this sort of discrimination, even if it does tend to win the approval of most voters. But since it happens that the charges for water used for public purposes are usually too low, and since more income is needed by water departments, we suggest the raising of hydrant rentals and other public service charges, not only because it will meet with less opposition but because it is equitable.

We have tacitly assumed that water revenues must be increased. When it is realized that existing water works could not be reproduced at present prices for less than a 75 per cent increase over the original cost, it should be apparent that annual maintenance and renewal expenses will hereafter average fully 75 per cent more than in prewar years. The wages and salaries of water works departments have not kept pace with increased costs of living, but they will have to be raised fully 60 per cent as compared with what they were before the war. Coal has doubled in price in most places. Taking these and other factors into consideration, it is safe to predict that the renewals, maintenance and operating expenses of water works will hereafter average fully 70 per cent more than before the war.

Waterworks superintendents and engineers should lay these facts promptly before city councils, mayors and chambers of commerce; and should ask for needed increases in rates for water. Coincidently they should point out that water waste surveys should be made and that water meters should be installed. Every effort should be made to reduce operating expenses, so long as adequate service is supplied; but adequate revenue should also be demanded.

A Suggestion to the Engineers of Philadelphia

A number of American cities make a practice of letting yearly contracts for garbage collection and disposal. Where a costly plant must be owned by the contractor, no real competition for the yearly contract is possible. The contractor who once secures the garbage disposal need fear no competitor.

Perhaps the best solution of the problem under such conditions would be the ownership of the plant by the city, and its operation by a contractor.

While a society of engineers should not undertake to design a plant for a city, it might well lead the public in establishing an economic policy. The Engineers' Club of Philadelphia is an unusually strong organization, and Philadelphia furnishes an exceptionally bad example of mismanagement as to garbage contracts. This great engineering club should lead in the fight, locally and in the state Legislature, to free the city from legal limitations as to garbage contracts.

E. & C. Index Furnished Only on Request

Previous to last year it had been our custom to send the index of our articles to all subscribers. In common with many other publishers we now have adopted the practice of sending the index to only such subscribers as request it. Therefore, if you want the index for the 6 months ending June 30 you should notify us at once. Those who requested the index for the previous volume have been listed and need not notify us again.

Frost Penetration at Taunton, Mass.—During the winter of 1917-18 frost penetrated the earth to the greatest depth known in the history of the Water Department of Taunton, Mass. In some places it reached a depth of 6 ft. On Nov. 24, 1917, a period of cold weather began which continued without cessation for four months. The surface of the ground was nearly bare. The snow fall for the entire period was 16½ in. but only about 3½ in. was on the ground at one time.

Book Reviews

Sewage Disposal.—By Leonard P. Kinnicutt, late Director, Department of Chemistry, and Professor of Sanitary Chemistry in the Worcester Polytechnic Institute; C. E. A. Winslow, Professor of Public Health in the Yale School of Medicine, and R. Winthrop Pratt, Consulting Engineer. Second edition rewritten. Cloth; 6x9 ins.; 547 pp.; illustrated. John Wiley & Sons, New York. $4.

This complete treatise on sewage disposal has undergone a thorough revision since the first edition published in 1910. The fundamental principles brought forth in the first volume have been largely retained but, the rapid progress in the art of sewage treatment has enabled the authors to add a great deal of new data.

Sewage disposal by dilution, the one method of treatment so habitually overworked, is discussed very thoroughly and the limiting factors are stated.

Other methods have been taken up in detail, principally in the order of their development. The use of bar screens and the many types of fine screens are discussed, and their efficiencies and costs of operation are presented. The various methods of preliminary treatment have been divided into treatment by chemical precipitation, by the septic process, and by 2-story tanks. A marked tendency in favor of the Imhoff 2-story tank has been apparent in recent years and the authors have given a great deal of data on this type of tank.

Final treatment of sewage is fully discussed with reference to broad irrigation, intermittent sand filtration, treatment in contact beds, trickling filters, and especially the comparatively recent activated sludge process. The underlying principles of this last method as they have been derived from extensive experiments in many places are valuable. Experience with this method of treatment is not general and the data presented have been collected from many sources hitherto comparatively inaccessible.

The disposal of sludge is generally a more or less difficult problem in treatment plants. Many methods are discussed together with the recovery of revenue producing by products. Recovery of grease from sludge produced by the Miles Acid Process is of particular interest because of the recent experiments at New Haven.

Questions of odors and other local nuisances from treatment plants, disinfection of sewage by chlorine, treatment plants for isolated places not connected to sewers, and other methods of sewage testing are other features brought out in this book.

One commendable feature throughout has been the attempt to give efficiencies and costs of the various methods of disposal.

Cost Estimates for Intercepting Sewer and Treatment Plant at Detroit, Mich.

Extensive studies of costs and methods of treatment of Detroit sewage have been made in connection with the recent Report of the Consulting Sanitary Engineer on the Pollution of Boundary Waters. One project recommended the immediate construction of two low level intercepting sewers discharging through pumps to two separate treatment plants.

The treatment plant consists of Imhoff tanks, including inflowing and outflowing channels; grit chambers; sludge drying beds; disinfection plant.

Imhoff tanks were proportioned on the basis of a sedimentation period of two hours, when the rate of flow equals 125 per cent of the average rate of flow, and storage room for sludeg of 2 cubic feet per tributary person. The estimate for grit chambers, bar screens, etc., was made by making an allowance of 5 ct. per tributary person, this figure having been arrived at from a review of published information regarding existing plants. The area of sludge drying beds required was based on a load of six persons per square foot of net drying bed area.

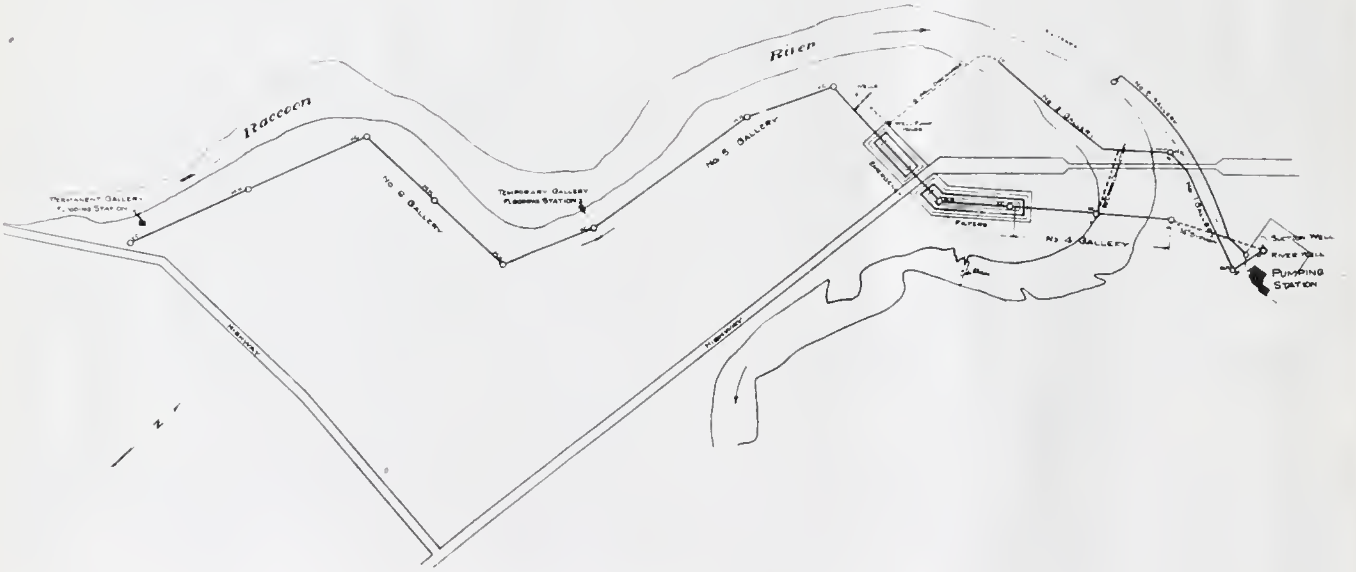
The total estimated cost of the treatment works for treating 162.7 M. G. D. from a population of 956,000 is $2,077,200 The cost per million gallons for the different elements is as follows:

Imhoff tanks	$8,559
Sludge beds	971
Screens and grit chamber	292
Disinfection	609
Covering ventilation and parking	2,336
Total estimated cost per M.G.D.	$12,767

The Gallery Collecting System of the Des Moines (Ia.) Water Co.

The Des Moines Water Co. is one of the pioneers, if not the first, to thoroughly develop its water supply by means of infiltration galleries. A number of cities have water supplies developed from the underlying sand and gravel strata by means of wells, but few, if any, have adopted the method used at Des Moines. An interesting description of the system employed at this city was given by Mr. A. T. Luce, Engineer and Superintendent of the Des Moines Water Co., in a paper presented April 16 before the Iowa Section of the American Waterworks Association. An abstract of the paper follows:

The water is obtained primarily from the Raccoon River. This stream lies in a southwesterly direction from Des Moines and discharges into the Des Moines River in the heart of the city. It has a drainage area of 3,677 square miles above the city and a minimum flow of sufficient quantity to more than meet the needs of the city for many years to come.



General Plan of Water Supply of Des Moines (Ia.) Water Works Company.

The most interesting feature of the river from a water supply standpoint is the geology of its valley in the vicinity of Des Moines. Here we find a broad valley nearly 100 ft. deep and a mile wide which has been eroded in the clay, shale and rock of the natural topography and extending for many miles upstream with relatively steep sides terminating in rolling plains above. It is evident that this valley was eroded by a preglacial stream which eventually cut its way to hard bottom and later covered this bottom with clean sand and fine gravel brought down from the glaciers and then, at a still later period, covered this gravel bed with from 5 to 10 ft. of alluvium. As might be expected, this stratum of sand and gravel terminates at the foothills on either side, but extends upstream for many miles. Borings have shown this to be true and many made by the water company affirm the fact that it is from 10 to 30 ft. in thickness, very clean and uniform in size. An analysis of the borings shows no marked difference in the character of the material, although in some places the sand predominates while in others the gravel. There is, however, little difference in the water carrying capacity, the average effective size being about 0.42 milimeters with a coefficient of uniformity of 4.00

Owing to the fact that the surface of the valley lies below the level of the flood plane of the river it is sparsely settled both within the city and for a long distance above it. Thus we find extending right into the city a large sand and gravel filled basin sealed off from practically all outside contamination by the topography and the natural clay soil, through which meanders a river of ample size to furnish the water requirements for many years to come. During the greater portion of the year this river is low in turbidity but is subject to floods that periodically scour the silt deposits from its bed.

It was concluded early in the development of the water company that the sand of the river would act as a good filtering agent and there was accordingly constructed in 1871 a steel tank 12 ft. in diameter and 14 ft. high with perforated sides and closed top. This tank was sunk in the gravel on the south bank of the river until its top was 10 ft. below water and it was surrounded with coarse gravel. It has been estimated that this tank furnished water at the rate of 1,500,000 gal. per day for short periods. A direct river inlet was later connected for emergency use.

In 1876 two more tanks were installed on the north bank of the river. These were very much similar to the original, being 12 ft. in diameter and 12 ft. high with perforated sides and open bottom but having tops constructed of 12-in. x 12-in. timbers.

The first unit of the present collecting system was built in 1882. This was the suction well located in the station yard and approximately 800 ft. from the river. It consists of a brick lined well 50 ft. in diameter and 35 ft. deep with walls 19 in. thick resting on an iron shoe. The well is roofed over below the ground and contains the suctions of the pumping engines. The top of the well is about 15 ft. above the normal river level. Upon completion the well was capable of delivering 500,000 gal. per day. With this well and the three boxes a supply of from 2,000,000 to 3,000,000 gal. per day was obtained although the draft upon the boxes was beginning to draw sand into the pumps and gave more or less trouble.

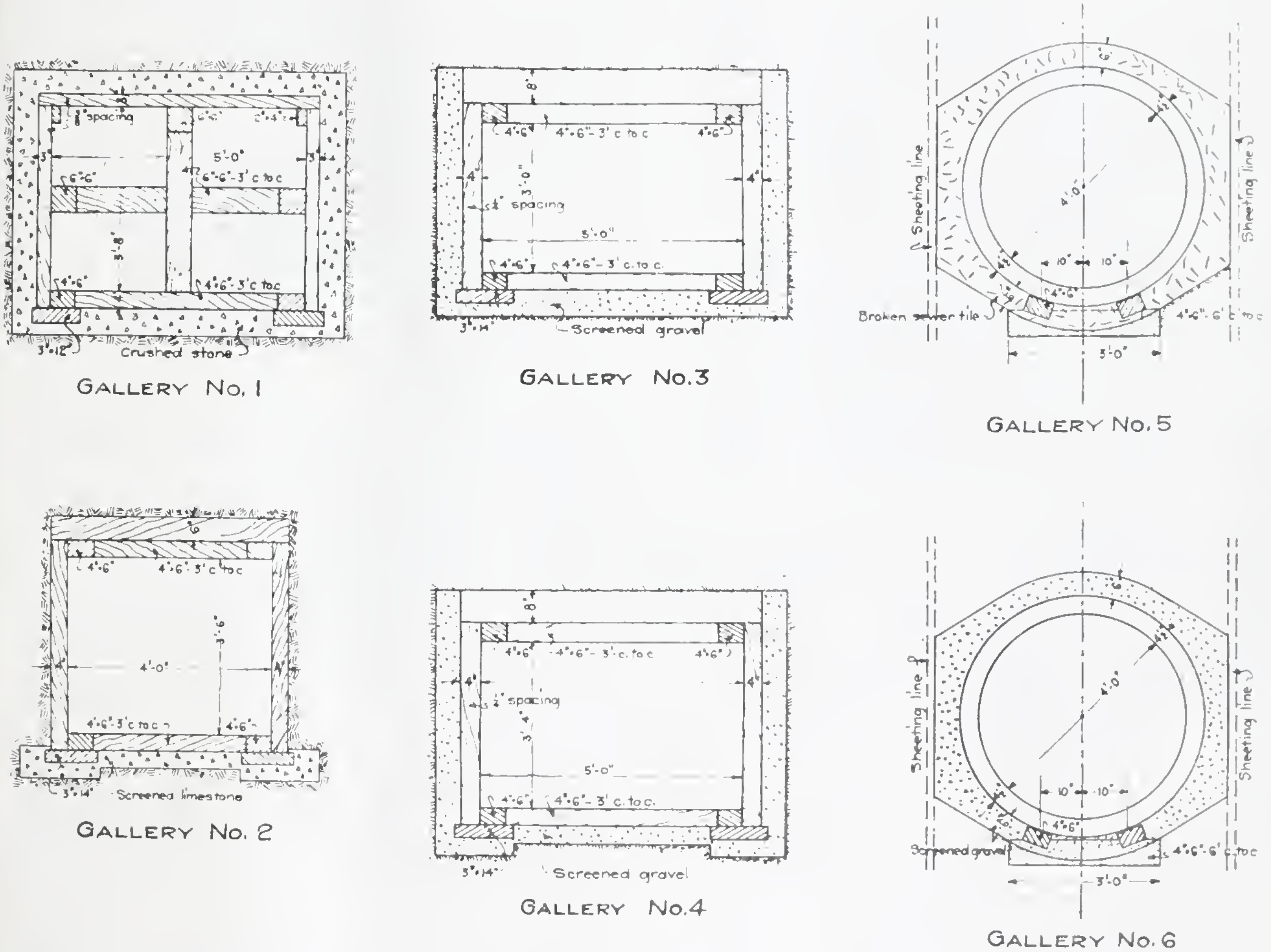
In 1884 work was started on the first gallery. This gallery is known as the No. 1 gallery and extends from the suction well south under the tracks of the Rock Island railroad a distance of 260 ft. thence in a westerly direction along the railroad between it and the river for a distance of 817 ft., terminating at a point 150 ft. from the river bank. It is 4 ft. high by 5 ft. wide and surrounded with 1-in. screened stone. The bottom is open and the sides and top are made of 3-in. x 6-in. white elm timbers laid with ⅜-in. spaces between. The gallery was built in open cut, the ditch varying from 17 ft. to 27 ft. in depth. It was completed in 1886.

The old iron tanks were abandoned in 1885 and the water drawn entirely from the No. 1 gallery and the suction well. Thus we find that 34 years ago the entire water supply was developed by infiltration at a considerable distance from the river.

Owing to the steady growth of the city and the increasing demand for water the No. 2 or river gallery and river well were built in 1887. The well was located in the station yard and is 20 ft. in diameter by 30 ft. deep built with 20-in. brick walls resting on a wooden shoe. It is roofed over with brick arches supported by I-beams. In order to prevent wash from the gallery one-half of the bottom is floored with a baffle in the center. This gallery is 1,594 ft. in length and lies along the foot of the bluff on the north side of the railroad terminating in an emergency inlet to the river. Like the No. 1 gallery it is constructed of white elm timbers in open cut varying in depth from 16 ft. to 30 ft. It is smaller, however, in size, being only 4 ft. wide by 4 ft. 2 in. high with open bottom and tightly sheeted sides and top made of 4-in. x 6-in. white elm timbers set on a bed of screened broken limestone. At the time of completion of this gallery there was ample infiltration to supply the domestic and fire demand of the city without recourse to the emergency river intake, the average daily consumption being about 2,000,000 gal.

It was not necessary to augment this supply by additional galleries until 1894 when the consumption had increased to an average of nearly 3,000,000 gal. per day. During this year the No. 3 gallery was constructed. This gallery is an extension of the No. 1 gallery beginning atthe end of the old gallery and extending across the river and upstream parallel to it for a total distance of 1,250 ft. It is 3 ft. 8 in. high by 5 ft. wide and was built with sides of 4-in. x 6-in. timbers in which ¼-in. spaces were left between timbers. The top was made solid, 8 in. in thickness, and, like the other two galleries, the bottom was left open. Screened gravel was placed on the sides and bottom of the gallery. For 150 ft. under the river the gallery is protected by a 4-in. concrete slab. A low brush and rock fill dam was thrown across the river below the galleries in the fall of this year which increased the head on the galleries about 2 ft.

Five 8-in. drive wells were constructed about 800 ft. from the gallery in 1899. These wells were about 20 ft. in depth, extending nearly to the clay subsoil and were equipped with 8-ft. strainers. Pumping was done by means of an electric driven pump which discharged into the end of the No. 2 gallery through a 16-in. C. I. pipe line. In 1900 it was decided that the operation of this equipment was determined to the flow in the galleries and the wells were accordingly abandoned.



GALLERY No. 1

GALLERY No. 3

GALLERY No. 5

GALLERY No. 2

GALLERY No. 4

GALLERY No. 6

Cross Section of Infiltration Galleries of Des Moines Water Co.

It was not until 1904 that additional galleries were built. The No. 4 gallery was started in 1902, but floods and high water delayed the actual construction for 2 years. This gallery forms the first link in the present main gallery line and was built of similar construction to gallery No. 3, although it is 4 in. higher, being 4 ft. by 5 ft. in section. It was built in open cut at a depth varying from 10 to 30 ft. and extends from a point on the north bank of the river 600 ft. from the suction well across the stream for a total distance of 1,600 ft. The end of the gallery is connected to the suction well by means of a 36-in. C. I. siphon. A 20-in. cross connection was built between galleries No. 3 and 4 in order to equalize their flow. It is of interest to note that this gallery extended at right angle to the river and at its upper end is 400 ft. from the nearest bank.

During times of low water it became necessary to irrigate and rake the sandbars along the river adjacent to the galleries in order to increase the yield. This procedure was expensive and more or less unsatisfactory and it was decided to extend the gallery system still further. After a careful investigation of the ground water contours and a further study of the water-bearing strata it was determined that over two-thirds of the water collected by the galleries came from the river and that the rate of this infiltration approximate 220,000 gal. per acre of river bed per day. It was accordingly concluded that extensions made parallel to the river would develop the greatest delivery.

Work was started on the No. 5 gallery in 1908. This gallery extends in a southwesterly direction from the end of gallery No. 4 a distance of 3,325 ft. and consists of a series of concrete rings 4 ft. in diameter laid on a timber cradle surrounded by 6 in. of crushed sewer tile. Each ring is 2 ft. long and 4½ in. thick, made of reinforced concrete and has small lugs cast on one end ¼ in. high which serve as spacers between the adjacent rings. The excavation ranged from 20 to 27 ft. in depth and due to the intensely water-bearing character of the material solid sheeting had to be resorted to. Three pumping plants were used during the work, as it was necessary to handle water at rates varying from 4,000,000 to 12,000,000 gal. per day. Manholes were built at points where the direction of the gallery changed. This gallery is divided into two sections connected by 36 ft. of 36-in. cast iron pipe and a gate valve. Cast iron pipe and valves were also placed at the beginning and end of the gallery. All three valves are located in valve chambers made of brick with concrete bottoms. The work on this section of gallery was completed in 1910.

In order to dispense with the irrigation and raking of the sand bars during periods of low water an emergency filter was built simultaneous with the construction of the No. 5 gallery. This filter consists of an earthen reservoir immediately above the gallery, divided into two sections by a street crossing. The filters are 30 ft. wide at the bottom with side slopes 1:1 and a total length of 850 ft., and are connected by a 24-in. vitrified tile. Water was originally admitted to them by gravity from the river through a 20-in. cast iron pipe. The bottom is at elevation 100 and the tops of the banks are at elevation 120. Without the emergency filter this gallery produced about 2,000,000 gal. per day and it was thought that there would be no further extensions needed for some time as the average daily consumption of the city was about 5,250,000 gal. per day. The demand for water, however, became greater than was anticipated as the consumption increased over 50 per cent between 1907 and 1913 at which time it became apparent that the galleries would have to be again extended and accordingly work was started on No. 6 gallery in the fall of 1914.

The No. 6 gallery begins at the end of Gallery No. 5 and parallels the river for a distance of 3,500 ft. It is identical in construction with the latter gallery and is likewise divided into two sections by a short stretch of 36-in. cast iron pipe and a valve. The excavation ranged from 18 to 20 ft. in depth and was done by two locomotive cranes operating on standard gage track on either side of the excavation. Steel sheet piling was used for lining the trenches and was driven by steam hammers supported by the cranes. Water was pumped from the ditch at rates varying from 2,000,000 to 8,000,000 gal. per day. This gallery was completed and put into operation early in 1917 and completes the extensions up to the present time.

Owing to the lowering of the river level about 2 ft. by sand dredging operations and the inadvisability of raising the brush and rock fill dam previously mentioned to a sufficient height to overcome this loss in head, it becomes necessary in 1916 to install a motor-driven low lift centrifugal pump of 5,000,000 gal. daily capacity to furnish water to the emergency filters during periods of drouth. This plant was replaced the first of this year by a permanent low lift pumping station located at the extreme end of No. 6 gallery. The station contains two motor-driven centrifugal pumps each of 5,000,000 gal. daily capacity which take their water from the river and discharge it into a series of ditches and pools extending along the land side of the gallery as far as the emergency filters. It has been demonstrated that this method of irrigation furnishes water of equal quality to that filtered from the river and that it filters at the rate of about 1,000,000 gal. daily per acre flooded. At present only one pump is operated and then during low water stages of the river, although the average daily consumption has grown to over 8,000,000 gal. daily and a maximum rate of 17,000,000 gal. daily was reached last August for a short time.

In the normal operation of the galleries the pumping engines at the pumping station lower the water level of the suction well by their demand and this unstable condition of the ground water level thus created causes a draft on the gallery conduits which in turn is replenished by infiltration from the adjacent water-bearing area. The ground water then flows from either side towards the gallery; the greatest amount, however, coming from the river side. During periods of high pumpage the ground water level immediately adjacent to the river has been drawn down to a foot below the level of the water in the river. This heavy draft does not increase the yield from the river as much as might be expected as it is limited by the permeability of the bed of the stream.

In conclusion it is of interest to note the bacterial results of the operation of this natural filter plant. A chemist and two assistants are regularly employed to observe the character and quality of the water, making daily analyses of water from the river, suction well, and tap. During last year the average daily bacterial count of the river, with samples incubated at 20° centigrade was 19,047 per cubic centimeter while that of the suction well, as filtered through the sands, was 1,061, showing a reduction of 94.5 per cent. The water is further treated with chlorine gas applied by an automatically operated machine which reduced the average daily count for last year to 47.5 or a total reduction of 97.5 per cent. It might be added that this average count at the tap is about double the normal actual count per day, the increased being due to a few high counts caused by abnormal fluctuations in the river.

High Rate of Filtration Recommended for Detroit

An experimental water filtration plant at Detroit, Mich., has been operated for one year to determine what type of purification plant and what method of operation are best calculated to improve the quality of Detroit water. A report to the Board of Water Commissioners which has been submitted recently by R. Winthrop Pratt, Consulting Engineer, Cleveland, O., contains the following conclusions drawn from the operating results:

The river water drawn through the present intake can be easily and satisfactorily purified by the process of rapid sand filtration. Its quality is well within the most severe standards fixed by sanitary authorities, for a filterable water.

It is feasible to use higher rates of filtration than has been the practice generally in the Middle West heretofor. This results in a decrease in the required area of filters and hence in a saving in the expense of constructing a filtration plant.

That, instead of three or four hours sedimentation period, as has been the more general practice, less than a two hours' period will be ample, thereby making another large saving in construction cost.

That the use of a filter sand having an effective size of approximately 0.50 m. m. gives just as good results as the use of a finer sand and results in a large saving of wash water.

That while sulphate of iron as a coagulant used in connection with lime gave good results, the use of this material with the local water required more careful supervision. The handling of two kinds of material instead of one makes for additional labor charges and increased construction costs.

That a filtration plant of sufficient capacity to filter all the water that can be drawn through the present intake can be constructed on the present water works property.

The report carries with it the recommendation of a 300 million gallon filtration plant and an auxiliary pumping station.

The principle features in the design of the filtration plant are two 2,000,000 gal. mixing basins, six 4,350,000 gal. coagulating basins, with a retention period of two hours, 72 filter units with a capacity of 4,000,000 gal. daily and a 36,000,000 gal. filtered water storage reservoir. A filtering rate of 174.2 mil. gal. per acre per day has been adopted. The effective size of the sand is also greater than usual, being from .45 to .50 m.m.

The cost of the project is estimated at $5,860,000, with an annual operating cost of $187,625 for filtration and $145,700 for low lift pumping. The total cost for pumping and filtration is estimated at $3.69 per 1,000,000 gal.

Returning Receipted Water Bills.—Discontinuance by the Water Department of Milwaukee, Wis., of the practice of returning receipts by mail remittances for water bills effected a saving of better than $300 in postage. In announcing this action the following foot note was printed in red ink on quarterly water bills: "Unless Requested, Receipts Will Not Be Returned On Mail Remittances." As receipts had, since the establishment of the water works, always been promptly returned for all remittances received by mail, the department was very skeptical as to the manner in which the public would view this change. However, no difficulty has been encountered and no complaints received from consumers. On account of the other public service utilities following a similar plan for some time the adoption thereof by the waterworks department was evidently not unexpected by the consumers. The plan has reduced the cost for postage for that particular service upwards of 75 per cent in addition to the labor saved in addressing and mailing.

Present Tendencies and Influence of War Period on Public Utility Commission Decisions*

By LEONARD METCALF,

Metcalf & Eddy, Consulting Engineers, Boston, Mass.

The writer has reviewed 500 decisions, more or less, affecting water works, handed down by courts and commissions during the 4½ year period from January, 1915, to May, 1919, hoping to be able to report to the American Water Works Association their more salient points, or at least the present tendencies and the influences upon them of the war period. The task proved too big for the time available, and he is therefore obliged to limit his comments to the impressions left by his investigation, rather than to attempt an exhaustive analysis of the decisions reviewed.

Public Ownership Losing Popularity.—Public ownership is less attractive to the people in the light of recent experience in public administration of public utilities in construction work—of the shipping board, the housing bureau, the railroads, the construction and other divisions of the army at home and abroad—and of the advance in prices ot labor and materials. The condition and service of the railroads and of the electric traction properties are far from satisfactory, and their present financial problems seem almost insolvable. Many of the great water works systems are in difficult positions financially. The government itself, as evidenced by the utterances of Mr. McAdoo, Mr. Hines and many others, has recognized the decline in morale under government ownership. The attitude of the great daily papers, the country over, in text and editorials, appears overwhelmingly opposed to its extension. Even the utterances of the church, through Cardinal Gibbons, reflect the same view.

Public Utility Commissions Have Greater Power.—The jurisdiction of the commissions in public utility regulation and control is constantly becoming more nearly complete. As the courts limit their action largely to questions of principle, reversals in the interpretation of fact by the commissions are rare. The practical effect of this, from the layman's viewpoint, is that, if the decision of the commission is sound in statement there is little hope of modification of findings, even though the conclusions reached seem to indicate that no substantial weight was given to certain elements of value or factors affecting it.

Valuation.—The commissions continue to tend strongly to original cost, as the fairest measure of value.

Many competent observers believe that past valuations or rating bases have frequently been too low, that the present decline in character or excellence of service clearly reflects this, and that the present rates on money are already, and the future rates will continue to be, higher in consequence of this tendency to undervalue. The difference between actual and assumed value may not always be great, but the tendency is to undervalue, and the influence is therefore usually in one direction. Its results appears likely to be disadvantageous to the public.

The failure of the rates prescribed by certain of the commissions in the past, to yield the revenue intended, gives further evidence that the companies are too often called upon to bear a burden of hazard of loss, disadvantageous to the public.

Overhead, Going and Franchise Values and Depreciation.—Overhead allowances have increased substantially, indicating that the commissions themselves, as a result of longer experience, recognize that their earlier allowances were too close.

While the recognition and inclusion of going value or development expense as a property element in the valuation of water works for purchase, sale, or rate determination, has been general and consistent on the part of the higher courts, the practice of some of the commissions appears in marked conflict to this position. The older commissions, however, generally recognize it, though the allowances for it are less than those accorded by financiers and operators in practice and in many actual sales.

Franchise values per se have shrunk markedly in the past decade, by contrast with the previous decade.

The general treatment of the depreciation [illegible] has improved immensely, as evidence has accumulated, and this evidence has borne out the contentions of [illegible] operators. The practice in the fixing of the annual depreciation allowance is generally fairer than in determining the accrued depreciation, but this difficulty is reduced by using the undepreciated value as the rating base.

The more equitable distribution of the burden of the rates is marked. The commissions have generally been steadfast in their insistence that the payment for fire protection service should be commensurate with its cost and that the distribution as between domestic and commercial or industrial service should also be equitably distributed according to cost, within the limitation of loss of business resulting from raising its cost beyond that at which the industries could supply themselves.

The position of the public service commissions has increased in power and recognition. Their ability and [illegible] has grown and broadened with experience. The good effect of continuity of service is as marked as is the retrogression due to change, until length of experience and service again makes themselves felt.

The mutual respect and cordial relations which exist between the commission and the corporation managers in many states, clearly reflect a better understanding of the real difficulties of the problem and of a desire on both sides to reach workable standards of service, which shall be of common advantage to the public and to capital, to the operators and the employers of public utilities.

The most serious differences of opinion generally arise through lack of understanding or full appreciation of the fundamental factors and difficulties of the problem.

Effect of Increased Cost on Rate Decisions.—The marked increase in cost of construction and operation is also reflected in the growing number of cases of advance in rates granted by the regulatory authorities.

A review of the waterworks decisions contained in the 24 volumes of Public Utilities Reports Annotated, published in the 4 years of 1915-1918, indicate the following approximate number of increases granted:

1915	Increases granted to 4 plants
1916	Increases granted to 12 plants
1917	Increases granted to 1[illegible] plants
1918	Increases granted to [illegible] plants

It is important to note that increases were few until the latter part of 1917, or early part of 1918, whereas the marked increase in cost of construction and operation, to water works, occurred in the latter part of 1916 or early part of 1918, whereas the marked Increase in cost of construction and operation, to waterworks, occurred in the latter part of 1916 or early part of 1917. This delay of 12 to 18 months was burdensome to the companies affected, more particularly to those with pumped supplies.

A reading of many of the decisions affecting water works and other public utilities, seems to indicate that it was the effort of the commissions to maintain the financial credit of the corporations, without attempting to make good the entire loss due to the war and abnormal conditions resulting.

Financial Burdens Due to the War Were Borne by the Water Works.—In its report to the last convention, the committee on "War Burdens of Water Works in the United States" called pointed attention to the letter of the Secretary of the United States Treasury, Mr McAdoo, addressed to President Wilson, under date Feb 17, 1918, in which he said:

"I earnestly hope that you may feel justified in expressing the conviction that the vital part which the public utilities companies represent in the life and war making energy of the nation, ought to receive fair and just recognition by state and local authorities."

And to the reply of President Wilson under date Feb 1[illegible], 1918:

"It is essential that these utilities should be maintained at their maximum efficiency, and that everything reasonably possible should be done with that end in view. I hope that the state and the local authorities, where they have not already done so, will, when the facts are properly laid before them, respond promptly to the necessities of the situation."

Reference was further made to the fact that the public service commissioners and other regulatory bodies in the United States had already [illegible] serious nature of the conditions confronting the public utilities properties, by granting, in certain recent cases, increase in rates or levying surcharges on existing rate-schedules, after careful review of the local conditions.

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*Abstract of a paper presented June 10 at the annual convention of the American Waterworks Association.

The question may now fairly be asked, "Did the regulatory authorities meet the situation?"

The issue is not raised here as to whether they should or should not have met the situation, nor how far sound public policy demanded that rates should be raised to meet the burden of increased expenses, but merely the question of fact—did the commission relieve the public utilities of their increased burdens due to the war?

To this question the answer must be "No," though many substantial increases were granted.

Whatever may have been the theory, principle, or motive governing the action of the regulatory authorities, it is a fact that the relief granted did not cover the change in conditions. It is apparent in the decreased, or suspended, return upon traction, gas, telephone and water utilities. The burden of the tremendous increase in operating expenses, taxes, and cost of money was borne largely by the utilities themselves—by the investor and not by the public—for the time being at least.

The data submitted seem to indicate that the increases granted to water works up to 1919 resulted in about a 10 per cent increment in net revenue and that in spite of this increase there was a net decrease of approximately 10 per cent.

The position of the regulatory authorities was a difficult one in view of the abnormal condition of the times and the war needs. Opinion may well be divided as to the limit to which it was wise for the commissions to go in relieving the corporations of their burdensome increase in costs. To the writer it seemed, and has always seemed, that such burdens could not practically be removed by the commissions promptly, because this would require too frequent revision of rates, but that the burdens should be recognized and distributed over a somewhat longer period of time, through an increase in return giving adequate margin for their amortization and for the establishment of reserves to cover the future hazard element.

The fact should be admitted, however, that the hazard of investment was not generally removed from the utilities by the regulatory authorities during the war, though relief was granted in many cases which helped to maintain the solvency of the corporations, and this was in some cases, at least, the goal sought.

Effect of the War Upon Water Works Revenues and Expenses.—The situation with regard to the water works of the United States is probably fairly shown by the following comparative records of about 50 plants with aggregate annual revenue of about $35,000,000 and supplying a total population of upwards of 9,000,000 persons or nearly 9 per cent of the entire population of the United States.

Table 1 shows the effect of war burdens upon the revenues and expenses of about 50 typical water works in the United States in the period from 1914 to 1918, both inclusive. The relative percentages of the records of each year are shown with reference to the prewar conditions which existed in the United States up to or slightly later than the end of the year 1915, assembled in four groups characterized as the Eastern, the Central, the Southern and the Western Groups of water works, the group percentages being substantially averaged to determine the general conditions prevailing over the country.

TABLE 1 EFFECT OF WAR BURDENS ON 50 TYPICAL WATERWORKS.

Gross Annual Revenue—Per Cent of Revenue for 1915.

Group—	1914.	1915.	1916.	1917.	1918.
Eastern	95.7	100	110.1	112.8	120.6
Central	98.3	100	109.1	111.4	126.4
Southern	97.7	100	107.5	120.3	126.3
Western	101.7	100	107.3	109.5	117.5
Average	98.3	100	108.5	113.5	122.7

Operating Expenses Including Taxes—Per Cent of Operating Expenses and Taxes for 1915.

Group—	1914.	1915.	1916.	1917.	1918.
Eastern	99.7	100	121.9	141.1	149.7
Central	100.9	100	109.3	137.3	162.3
Southern	97.6	100	109.7	134.6	165.9
Western	98.6	100	109.9	117.4	128.0
Average	99.0	100	112.7	132.6	151.5

Net Revenue Applicable to Depreciation, Interest, Dividends and Surplus—Per Cent of Net Revenue for 1915.

Group—	1914.	1915	1916.	1917.	1918.
Eastern	90.9	100	103.0	90.4	105.8
Central	97.3	100	110.0	98.5	106.5
Southern	97.9	100	96.3	104.0	89.1
Western	103.6	100	104.3	105.3	114.4
Average	97.4	100	103.4	99.6	101.0

The annual revenue with such increase in rate schedules as were granted by the regulatory authorities and put into effect by the plants, have increased at an average rate of approximately 7 per cent per annum, slightly less than a normal amount.

The operating expenses, including taxes where taxes were paid, and excluding them where none are paid, have increased over the year 1915 abnormally—by 13 per cent in the year 1916, 33 per cent in the year 1917 and 52 per cent in the year 1918.

The net (operating) revenues applicable to depreciation, interest, dividends and surplus, have substantially stood still since the year 1915.

The average increase in population in this country has been at the rate of approximately 1.9 per cent, compounded annually, and of the cities supplied by these 50 typical water works, about 3.1 per cent.

The net revenue of water works usually increases at the rate of from 4 to 5 per cent,* compounded annually. Yet the total increase in the three-year period from 1915 to 1918 is but 4 per cent against a normal amount of from 12 to 15 per cent, in spite of increases granted by the commissions.

The records indicate further that the increases in rates granted to water works by the commissions seems to have amounted on the average to about 10 per cent, serving thus to decrease the loss in net revenue in the year 1919 from 20 per cent, more or less, to 10 per cent or thereabouts. If this inference is sound, the loss in operation was divided equally between the works and their consumers.

It is clear, however, that the burden of increased operating expenses plus the interest upon the new investment put into these properties during the war period, has been borne by their owners in larger measure than by the public, except in the case of publicly owned works.

Ditching With Dynamite in Anti-malarial Drainage Work

In connection with the anti-malarial preparations of the U. S. Public Health Service in the extra cantonment zone at Camp Wheeler, Ga., dynamite was used in the ditching work. The best results were obtained in mucky areas where the mud was so deep and soft that hand excavation became slow and difficult. In these cases, the use of dynamite proved satisfactory. In a report on the work by the U. S. Public Health Service the following comparative costs of ditching by hand labor and with dynamite are given. The figures are for two adjacent ditches in a large swamp in the extra cantonment zone. Ditch No. 60 was excavated with dynamite. This ditch was 2,802 ft. long, 12 ft. wide at the top and 4 ft. wide at the bottom, and averaged 5 ft. deep. The number of cubic yards of material removed was 4,151. Ditch No. 62 was excavated by laborers with picks and shovels. This ditch was 3,591 ft. long, 4 ft. wide and 3 ft. deep. The yardage was 1,596. The cost of excavation in the case of ditch 60 includes clearing out the ditch after it was dynamited. In the case of ditch 62 the cost of excavation includes the cost of a small quantity of dynamite used to facilitate the removal of large stumps. The costs of excavating each ditch, not including clearing, were as follows:

	Ditch 60.	Ditch 62.
Cubic yards	4,151	1,596
Labor cost	$308.90	$671.75
Cost of material	$1,265.10	$38.75
Cost of excavation	$1,574.00	$710.50
Cost per cubic yard	$0.39	$0.45
Man days at $3	103	224
Man days per cubic yard	0.024	0.140
Cubic yards per man day	41.66	7.14

The report states that it is probable that the cost of excavating ditch 60 by hand would have greatly exceeded 45 ct. a cubic yard, owing to the very difficult nature of the soil—a mass of yielding mud, largely under water, in which it was almost impossible to stand up.

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*A recent analysis by the writer of the increase in operating revenue (applicable to depreciation, interest, dividends and surplus) in 19 different waterworks during the 5-year pre-war period from 1910 to 1915, showed an average rate of 4.11 per cent compounded annually.

Friction Tests and Capacity Table for Cement Pipe

Since 1907 a large amount of cement pipe has been laid in Arizona for irrigation projects. In California it is estimated that over 5,000 miles of such pipe has been constructed for irrigation lines. Interesting data on internal friction tests of this type of pipe are given in a bulletin prepared by Mr. G. E. P. Smith, Irrigation Engineer of the University of Arizona, and issued recently by the Agricultural Experiment Station of the University.

Friction Tests at University Farm.—Tests to determine the friction loss in hand-made cement pipe were made at the University Farm in 1916. The object was to furnish a basis for the design of two additions to the distributing system.

All of the old line was 12 in. in diameter and all except the first 360 ft. was built with rectangular outlet boxes spaced every 36 ft. These boxes are 22 in. long by 30 in. wide, and have two discharge notches at the top, one toward the right of the pipe line, one toward the left. The flow of water expands on entering a box and contracts on leaving, so that there is a considerable loss of head in each box. The design is not to be recommended.

In making the tests, the discharge of water was measured over a weir just before entering the pipe line, and the water levels were noted in each box by measuring down from a point on the top. A line of levels had been run to determine the elevations of the points on the tops of the boxes. The cement pipe when new had received a coat of neat cement wash on the inside surface.

After the additional pipe line had been laid in the summer of 1916, pipe friction tests were made in that portion which had 12-in. outlet risers and valves of the California pattern; that is, the riser is a joint of pipe cemented into an opening in the top of the pipe line. In this case the loss of head must be moderate since the flow of water is expanded on the top side only, the filaments of water on the lower side moving in straight lines. The results of all the tests are given in Table I.

While pipe friction tables are easily available, data on the effect of boxes and risers have not been published. The value obtained in the straight pipe without risers corresponds to a value of "n" in Kutter's formula of .013. This is the value most used for cement and concrete surfaces.

Tests of Pipe for Continental Ranch Irrigation System.—Tests of pipe friction were made at Continental in 1917. The flow of water is northward from the pumping plant through about a mile of machine-made pipe, thence eastward across the railway and through a quarter mile of [illegible] hand-made pipe. Readings were taken at the several gate pits built at intervals along the line. There are no outlet risers on the line of pipe as tested except in the [illegible] where the risers are [illegible] ft. apart. A summary of the tests is given in Table II.

Tests were made on three different dates. Considerable difficulty was experienced in getting consistent results in these tests. For example, in the first set of tests the friction losses between Lateral No. 2 and the railroad crossing appeared to be inexplicably large. In the tests as repeated on Sept. 27, the loss between Lateral No. 2 and Lateral No. 3 is too great.

It was thought at first that the reason might be that considerable portions of the pipe were not running full even though all pipe ends in the gate pits were well covered. This hypothesis was disproved when it was found that the friction losses were less in the second set of tests, although the water levels in the gate pits were lower than in the first set. A better explanation is that in the long line running north from the pump to the railroad on a descending grade a great deal of air is trapped. This air cannot work back upstream against the water friction, and so it is slowly rolled along downstream until it escapes at the gate pits. At one gate pit, it was noticed that great globules of air from one to three quarts at a time, were coming out of the pipe line at intervals of about a minute, 1 hour and 40 minutes after the gates had been adjusted. On the east side of the railroad this effect was not encountered. On that side the line has an ascending grade and the entering water doubtless carries all the air out promptly.

The important bearing of these observations is that as in many other lines of design, a factor of safety is necessary in designing pipe lines on descending grades and, furthermore, there should be many air vents or open stand pipes on descending grades. In computing capacities, pipe lines are assumed to be running full of water, but no recognition is made of possible unfavorable conditions. It is interesting to note from Table II that the friction loss between Lateral No. 3 and the railroad was 13 per cent greater in one test made 18 minutes after adjusting the gates than in another test made 3 hours and 20 minutes after adjusting the gates. Also, in the same line, on Oct. 8, with a discharge of 2.08 second-feet, the loss of head decreased from [illegible] ft. 37 minutes after adjusting the gates for this test to 8.22 ft. one hour after adjusting the gates and 8.00 ft. 1 hour and 24 minutes after adjusting the gates.

From all the above tests it may be concluded that the friction factor, "n," for hand-tamped and washed pipe is [illegible] and for machine-made pipe the factor is a little less than .013. This assumes that the joints are well made by careful workmen. If it is assumed that the joints will be left rough and projecting on the inside, then the designers should use a friction factor of .014 or .01[illegible].

Capacity Tables.—As a basis for determining the proper sizes of pipe required in the design of any particular project Table III has been prepared. This table is compiled from Kutter's formula, using a friction factor of .013. This is a conservative basis for straight lines without risers, and well executed machine-made cement pipe lines may have somewhat greater capacities than those given.

In the case of lines with tee risers of the same size it may be about right to assume an increase of friction loss of 12½ per cent for each riser in 100 ft. of pipe. Thus if the risers are spaced 50 ft. apart, increase the allowance for friction 25 per cent; if they are spaced [illegible] ft. apart, increase the allowance about 38 per cent. Sometimes tee risers of greater size than the pipe line are used. In such cases the increase in friction loss will be less than 12½ per cent for each riser in 100 ft.

TABLE I.—FRICTION LOSSES IN HAND-MADE CEMENT PIPE AT THE UNIVERSITY FARM.

Pipe line.	Discharge. Second-feet.	Loss of head per 100 feet Feet.	Increase in loss. Per cent.	Loss per box or riser. Velocity-heads
Straight, no boxes....	1.6	.222	..	....
Rectangular outlet boxes every 36 ft....	1.6	.368	66	0.87
Circular outlet risers every 36 ft..........	1.6	.300	35	0.47

TABLE II—FRICTION TESTS ON CEMENT PIPE LINES AT CONTINENTAL.

From	To	Dis. Ft.	Dia. In.	Discharge Sec.-ft.	Loss of head Ft.	Time after adjusting gates Hr. Min.	Value of "n"
April 26, 1917.							
Lateral No. 2	Lateral No. 3	897	14	2.44	2.85	0 18	.....
Lateral No. 3	R. R. Crossing	2,063 1,100	14 12	2.41	11.83	0 18	.....
R. R Crossing	Riser No. 4	1,120	16	2.15	0.99	0 18	.013
Sept. 27, 1917.							
Lateral No. 2	Lateral No. 3	897	14	2.49	2.77	1 40	....
Lateral No. 3	R. R. Crossing	2,062 1,100	14 12	2.49	9.82	1 10	.0121
R. R. Crossing	Riser No. 4	1,120	16	2.36	1.09	1 40	.013
Oct. 8, 1917.							
Lateral No. 2	Lateral No. 3[1]	897	14	2.08	1.59	1 02	[illegible]
Lateral No. 3	R. R. Crossing[2]	2,063 1,100	14 12	2.08	8.67	[illegible]	...
Lateral No. 3	R. R. Crossing[3]			2.08	8.22	1 02	[illegible]
Lateral No 3	R. R. Crossing[4]			2.08	8.00	1 [illegible]	.013
R. R. Crossing	Riser No. 4[1]	1,120	16	2.00	0.82	1 02	.01[illegible]
Oct. 8, 1917							
Lateral No. 2	Lateral No. 3[4]	897	14	2.49	2.13	3 20	[illegible]
Lateral No. 3	R. R. Crossing[4]	2,063 1 100	14 12	2.15	[illegible]	[illegible]	[illegible]
R. R. Crossing	Riser No. 4[4]	1,120	16	2.38	[illegible]	[illegible]	[illegible]

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[1] 3:00 p. m. [2] 2:35 p. m. [3] 3:22 p. m. [4] 5:20 p. m.

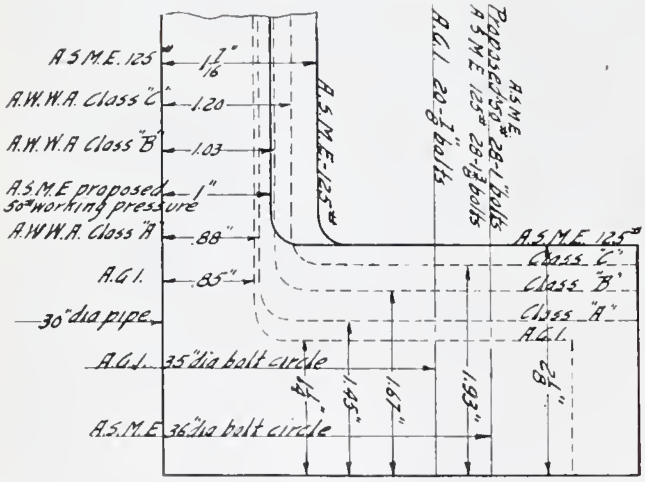
TABLE III—CAPACITIES [illegible]

[illegible]

The horizontal lines which occur in Table III indicate the minimum grades allowable for each size of pipe in cases where the water carries must sediment. For example, a 12-in. pipe line must have a fall of at least 0.4 ft. per hundred feet in order to prevent the deposition of sand in the pipe. In case the water is clear or can be passed through a settling basin before entering the pipe, the flatter grades can be used, or perhaps the line can be flushed out occasionally through cleanouts.

Standardization of Flanges for Light Cast Iron Pipe

The desirability of an early standardization of flanges for light cast iron pipe was pointed out by Mr. John Knickerbocker, president of the Eddy Valve Co., in a paper presented at the recent annual convention of the American Waterworks Association. In connection with the paper the illustration reproduced below was presented. This shows the thicknesses of pipe, and thicknesses of flanges for American Waterworks Association Classes A, B and C pipe, the flanges for these pipes being calculated by the formula, thickness of flange equals 1½ times thickness of pipe, plus ⅛ in.; the thicknesses of pipe of the American Gas Institute, and the thicknesses of flanges and bolt circles adopted by them; the American Society of Mechanical Engineers proposed standard for 50 lb. working pressure, and the American standard for 125 lb. steam working pressure.



Mr. Knickerbocker stated that there is a serious question if the standard flange suggested by the American Society of Mechanical Engineers for pipe for 50 lb. working pressure is not too heavy and will not cause casting strains and shrinkage where the flange meets the pipe. Further extracts from his paper follow.

Take for example the 30 in. pipe, the Class A, American Waterworks Association pipe measure 0.88 in. thick. Would it be good foundry practice to cast a flange measuring 2⅛ in. thick to this thin pipe, and if the pipe were increased in thickness about ⅛ in. to 1 in. thick, the thickness proposed by the American Society of Mechanical Engineers for 50 lb. working pressure, would not the flanges 2⅛ in. thick be too heavy for the pipe?

The American Gas Institute pipe thickness for 30 in. pipe is 0.85 in. Taking the inside diameter of the flange at 31.7 in. on this 30 in. pipe, as 31.7 in. is the outside diameter of the pipe, the weight of the American Gas Institute flange is 102.4 lb. and the flange proposed by the American Society of Mechanical Engineers for light pipe is 215.5 lb., which is over twice as much as the American Gas Institute 30-in. flange. If the American Gas Institute flange is heavy enough for Class A pipe, then for each flange 113.1 lb. would be wasted if the American Standard flange were used; besides the poor casting that might result from casting such a heavy flange on a light pipe.

If a flange 1.67 in. thick were used on a 30-in. Class B pipe, taking the outside diameter of the pipe as the inside diameter of the flange, it would weigh 169.38 lb. The American standard flange on this pipe would weigh 215.5 lb., showing a saving of 46.12 lb. per flange.

If it were possible to use the American Gas Institute flange for the Class A pipe, and a flange of the diameter of the American Standard but between the thickness shown for the flanges for Class A and Class B pipe as calculated by the formula given on page one, it might be a good solution of the question.

Would it not be a good idea for the committee of this association which has this matter in charge, to endeavor to take it up with like committees from the New England Waterworks Association, the American Society of Mechanical Engineers, the American Gas Institute, the Cast Iron Pipe Manufacturers, the Committee of Manufacturer on Standardization of Fittings and Valves, and such other organizations as might wish to be represented.

Original Cost and Estimated Life of Rockford, Ill., Waterworks.—The following tabulation from the last annual report of the Water Department of Rockford, Ill., showing the value of the entire property of the department at the end of Dec. 31, 1918, gives some interesting information on the original cost and the estimated life of the various items of the waterworks:

Items.	Original cost.	Years life.	Present age.	Total present value.
Distribution System:				
Water Mains with all Valves and Specials:				
Under 2 in.... 4,828 ft.				
2 in.... 40,330 ft.				
3 in.... 2,772 ft.				
4 in....117,717 ft.				
6 in....371,446.1 ft.				
8 in....109,067 ft.				
10 in.... 19,714 ft.				
12 in.... 35,612.6 ft.				
16 in.... 2,670 ft.				
20 in.... 3,624 ft.				
24 in.... 100 ft.				$716,611
Shaft and tunnel system	$46,132	50	20	35,934
Water piping and appurtenances at station, including conduits, etc.	7,569	50	18	6,104
Reservoir No. 1, built 1883, rebuilt 1913	18,891	60	5	17,389
Reservoir No. 2, built 1912	19,662	60	6	18,895
Wells at plant in Peach St	26,500	..	27	7,590
Well No. 7, 11th St. and 18th Ave.	10,301	40	5	9,704
Well No. 8, Hulin Park	10,488	40	2	10,302
921 fire hydrants	64,853	40	20	47,926
Drinking fountains, water tanks and street stand pipes	.....	..	..	1,437
Waterworks hand tools and tool equipment (inventory)	.....	..	..	3,431
Motor driven deep well pump—No. 7	5,138	20	5	4,297
Motor driven deep well pump——No. 8	5,782	20	2	5 454
10-in. Venturi meter, well No. 8	560	40	2	547
Snow engine, 10,000,000 gal. capacity	36,613	40	11	30,833
Holly-Gaskill engine, 6,000,000 gal. capacity	26,854	30	26	*5,000
Holly-Gaskill engine, 3,000,000 gal. capacity	13,864	20	25	*1,200
Mead system—Engines and condensers—Pumps, suction and discharge	9,933	20	20	*2,500
Impeller pumps for wells No. 3 and 5	13,351	20	20	*3,500
Steam pipings	6,736	10	7	*3,500
Boilers—Return tubular (2)	2,545	20	23	*180
254 hp. water tube boiler, 1918	10,800	20	18	*2,700
Boiler feed pump, 2 stoker engines	10,988	20	..	'0,988
Recording instrument and boiler meter	2,014	15	17	*350
Ash conveyor, 1- 6-in. Worth meter	.....	..	..	......
Sirroco fan—Well No 8	122	40	2	120
Remote control wire, Well No. 8—(Inventory)	.....	..	..	430
Wagon scales, erected 1915, Central Station	329	20	3	304
Transportation equipment	.....	..	..	1,670
Office equipment and maps (Invty)	.....	..	..	4,200
Pumping station building, Central Station	28,677	50	28	18,574
Pumping station building, Well No. 7	1,617	30	5	1,566
Pumping station building, Well No. 8	7,758	50	2	7,600
Water works shop	5,605	40	21	2,598
Reinforced concrete stack, Central Station	4,722	60	11	4,360
Real estate, Central Station site	15,000	..	..	75,000
Real estate, 2 lots Highland, proposed elevated tank site	1,400	..	..	1,650
Real estate, 2 lots, Well No. 7	1,429	..	..	1,650
Total property evaluation, Dec. 31, 1918	.....	..	..	$1,065,349

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*Fixed.

Cost of Labor and Material for Construction, Operation and Maintenance of Waterworks

Interesting data on the cost of labor and materials for waterworks were given by Mr. Leonard Metcalf of Metcalf & Eddy, Consulting Engineers, Boston, Mass., in a paper presented June 10 at the Buffalo convention of the American Waterworks Association. Figures were presented showing the relative increases in labor and material cost for about 50 waterworks having an aggregate annual revenue of about $35,000,000 and supplying a total population of approximately 9,000,000. The basic information given was reported in a 1918 report of a committee of the American Waterworks Association. (See Engineering and Contracting, Aug. 14, 1918.) The figures in this report have been brought down to date of Dec. 31, 1918, by Mr. Metcalf. Table I is a summary of the data.

Cost of Common Labor.—Unskilled labor costs, in cents per hour, did not generally feel the influence of the war until the middle of the year 1916. As compared with pre-war conditions, reflected by the prices prevailing in 1915, they increased one-eighth in the year 1916, one-fourth in the year 1917, and nearly three-fourths in the year 1918. It is interesting to note further that the increase was felt most markedly in the south and upon the eastern seaboard, being nearly doubled in the first, and increased by three-fourths in the latter district.

The wages paid upon the Pacific Coast before the war, which were much higher, have advanced relatively less than elsewhere, so that at the present time the eastern and western unskilled labor prices are about the same. Thus the average rate in the western group increased from 27 ct. per hour in 1915 to 42 ct. in 1918; while the southern rate increased from 18 ct. to 34 ct.; the central group from 22 ct. to 37 ct., and the eastern group from 23 ct. to 40 ct.

It is important to note further that even these rates are probably below current comparable rates for other labor.

Recent Data Upon Labor Prices of April, 1919, Paid by Waterworks in the Vicinity of Boston.—It is interesting to note that in spite of the general business uncertainty and resulting depression, wages paid to unskilled labor by waterworks in the vicinity of Boston have advanced from approximately 41 ct. per hour, as reported under date Sept. 14, 1918, to approximately 46 ct. per hour in April, 1919, without allowance for the effect of vacations and holidays under pay, granted by some works, as shown by Table II. Present (June, 1919) conditions give little if any indication of reduction in prices this year or hope for any [illegible] in the future.

TABLE II.—LABOR PRICES PAID BY WATER WORKS IN THE VICINITY OF BOSTON, APRIL, 1919.

Place	Common labor, per day.	Common labor, per hour.	Pipe layers and caulkers per day.	Pipe layers and caulkers per hour.	[illegible]	[illegible]	[illegible]
Boston	$3.00	$0.41	$3.25-3.50	$0.444-0.4[illegible]	44	Not paid	[illegible]
Somerville	3.25	0.443	3.75	0.476	44	Not paid	[illegible]
Newton	3.25	0.443	3.50	0.477	44	Not paid	[illegible]
Lexington	3.25	0.406	3.50	[illegible]	48	Not paid	[illegible]
Waltham	3.25	0.443	3.50-4.50	[illegible]	44	Not paid	[illegible]
Everett*	3.75	0.511	4.25-4.50	0.579-0.61[illegible]	44	Paid	[illegible]
Malden	3.50	0.477	4.00	0.545	44	[illegible]	[illegible]
Chelsea	3.25	0.406	3.75	0.468	4[illegible]	Paid	[illegible]
Quincy†	4.00	0.543	4.50	0.613	4[illegible]	Paid	[illegible]
Medford	3.50	0.477	3.75	0.511	4[illegible]	Paid	[illegible]
Melrose	3.50	0.477	4.00	0.547	44	Paid	Yes
Revere	3.50	0.477	3.75	0.511	44	Paid	[illegible]
Watertown‡	3.50	0.477	3.75	0.511	44		
Arlington	3.75	0.511	4.25	0.579	44	6 out of [illegible]	[illegible]
Milton	3.50	0.477	3.93	0.535	44	Paid	[illegible]
Winthrop	3.50	0.437	3.75	0.468	48	Paid	[illegible]
Cambridge	3.50	0.477	3.75-4.00	0.511-0.545	44	Paid	[illegible]
Brookline	3.50	0.477	4.17	0.568	44	Paid	[illegible]
Marlboro	3.50	0.437	3.75	0.468	48	Not paid	No
Hudson	3.50	0.437	3.75	0.468	48	Not paid	No
Fitchburg	3.36	0.42	....	...			
Fitchburg	3.60	0.45	...	...	48	Not paid	[illegible]
Fitchburg	3.92	0.49	....	...			

Average ......46.1 ct.

16 allow 2 weeks' vacation. 11 pay for holidays. [illegible] allow Saturday half holiday under full pay.

*In Highway Department, $3.50—47.7 ct. per hour.

†High, account government activities.

‡50 ct. bonus per day for those who work one year.

Material Prices.—Cast iron pipe prices, which had about trebled at their maximum point, have now receded to about 2 times pre-war figures.

Valves, hydrants and pumps, which had more than doubled in price, are now to be had at an advance of something over seven-eighths of pre-war prices.

Coal and fuel prices, which more than doubled, have receded somewhat.

Chemicals used in the purification of water, which, by reason of outstanding contracts showed an average advance of but one-third, though the market price had increased approximately three-fourths, have decreased so that the present excess cost is about one-half over pre-war prices.

$25,000,0000 Irrigation Project in Australia.—An irrigation project calling for the reclaiming of large tracts of land in New South Wales, Victoria and South Australia will be undertaken by the Australian government. The scheme involves an expenditure of $25,000,000 and includes the construction of a dam 300 miles southwest of Sydney.

TABLE I.—SUMMARY OF DATA UPON INCREASE IN COST OF LABOR AND MATERIALS TO WATER WORKS IN THE UNITED STATES, AS REPORTED TO THE EXECUTIVE COMMITTEE OF THE AMERICAN WATER WORKS ASSOCIATION, MAY 1918, REVISED APRIL, 1919, BY LEONARD METCALF.

		Prices per unit.				Per cent increase over 1915			Year 1918 Assumed by Metcalf		
Item.	Number of records.	1915. Ct.	1916. Ct.	1917. Ct.	3 mos. 1918. Ct.	1916. Per cent	1917. Per cent	3 mos. 1918. Per cent	No. of records	Cost [illegible] Ct.	Per cent increase over 1915
Unskilled labor,* in ct. per hour—											
(a) Western group	7	27.0	28.5	31.4	Still increasing in 40.6 per cent of all groups	5	16	Still increasing in all groups	8	41.8	[illegible]
(b) Central group	12	21.7	25.3	26.9		17	24		10	37.2	[illegible]
(c) Eastern group	15	23.0	26.7	30.4		16	32		18	40.2	[illegible]
(d) Southern group	10	17.9	20.6	24.5		17	37		12	[illegible]	[illegible]
(e) Average of groups (4)	..	22.4	25.3	28.3		13	27		4	[illegible]	[illegible]
(f) Average of all	44	22.1	25.2	28.3		14	28		48	[illegible]	[illegible]
Cast iron pipe, per 2,000 lb.	21										
6-in. valves	11	$24.23	$30.70	$51.60	......	26.7	112.9			$[illegible]	[illegible]
12-in. valves	3	$11.18	$12.64	$19.13	$23.20	13.1	71.1	107.0	23	$[illegible]	[illegible]
2-way hydrants	6	$34.78	$41.53	$65.22	$69.00	19.1	87.6	98.7	10	[illegible]	[illegible]
Coal, per 2,000 lbs.—		$26.69	$32.04	$43.13	$53.90	20.1	61.6	[illegible]	[illegible]	[illegible]	[illegible]
(a) Eastern group	13	$2.98	$3.80	$5.96	$7.04	27.5	100	[illegible]	[illegible]	[illegible]	
(b) Central group	11	$2.41	$2.77	$3.75	$6.38	[illegible]	56.4	164.[illegible]	7	[illegible]	[illegible]
(c) Southern group	12	$1.92	$2.01	$3.03	$4.02	4.7	57.8	10[illegible].4	10		[illegible]
(d) Western group	5	$3.97	$4.37	$6.31	$7.89	10.1	58	98.7	8	[illegible]	[illegible]
(e) Average of groups (4)	..	$2.82	$3.21	$4.77	$6.33	[illegible]	69	[illegible]	4	[illegible]	[illegible]
(f) Average of all	41	$2.62	$3.04	$4.52	$5.69	[illegible]	73.7	11[illegible]	4[illegible]	[illegible]	[illegible]
Fuel oil, ct. per gal., South	1	1.80	1.80	2.00	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]
Fuel oil, ct. per gal., West	1	1.38	1.50	[illegible]	[illegible]		[illegible]			[illegible]	
Alum, ct. per lb.—											
(a) Western group	2	1.14	1.21	1.51		[illegible]	[illegible]			[illegible]	[illegible]
(b) Central group	5	0.91	0.91	1.2[illegible]		[illegible]	[illegible]			[illegible]	[illegible]
(c) Eastern group	9	1.12	1.72	[illegible]			[illegible]		[illegible]	[illegible]	[illegible]
(d) Southern group	9	1.08	1.38	[illegible]			[illegible]			[illegible]	[illegible]
(e) Average of groups (4)	..	1.06	1.30	1.42			[illegible]			[illegible]	[illegible]
(f) Average of all	25	1.07	1.10	1.41		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
(g) New York market price†	**	2.08	1.63	2.57	[illegible].15			[illegible]			

*Note.—It was generally reported that there has been also [illegible] estimated at between 20 and 50 per cent, and that the increase in [illegible] labor [illegible] contract prices, owing probably to the advantage of continuity of service.

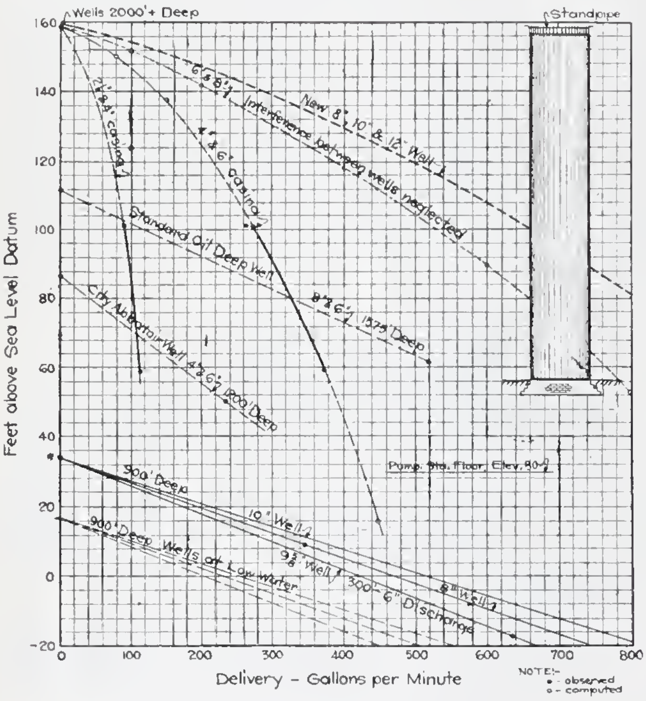
†See Journal of Industrial and Engineering Chemistry. Note that 1915 price was an advance of [illegible] per cent [illegible] before the advances listed went into effect.

‡5 months. **Average monthly prices.

Artesian Well Supply at Baton Rouge, La.*

By L. R. HOWSON,
Principal Assistant Engineer, Alvord & Burdick, Chicago.

Many localities have no ground water supplies available at any cost, others but limited ones, and a few are blessed with adequate and satisfactory supplies from underground sources, but there is no section which can furnish ground water supplies more satisfactory in quality and under so many varying conditions of pressure, temperature, yield, and depth as are found in the Mississippi River Delta near Baton Rouge, La.



* The Static Level has been measured by Mr. Connell at about Elev. 17

Relation Between Yield of Wells and Lowering of Static Water Levels.

The Baton Rouge Water Works Co. has been the pioneer in exploring the underground water resources of this locality, which now furnishes such an abundant supply for the city of Baton Rouge and the large oil refineries and other industries there.

At Baton Rouge (which is about 40 ft. above sea level) the water company's wells furnish the following data:

(a) Wells at 200 ft. to 400 ft. deep have a static elevation near sea level; the temperature of the water is 64°, and it is high in organic matter.

(b) Wells at 800 ft. to 900 ft. deep penetrate a 50 ft. layer of sand, which yields a plentiful supply of water whose temperature is 72°. The static level is 35 ft. above sea level, and tubular wells from 6 in. to 12 in. in size will show a specific capacity or yield for each foot the static water level is lowered, of from 10 to 12 gals. per minute.

(c) Wells at 1,320 ft. to 1,350 ft. penetrate a sand layer in which the static water level rises to 110 ft. above sea level. The water has a temperature of 85°, and wells have a specific capacity of but from 1 to 2 at the water works, and 6½ at the city well recently drilled.

(d) At 2,050 ft. a 60-ft. sand layer is penetrated which produces wells having specific capacities of 12 to 15, and a temperature of 92°. The static water level is 160 ft. above sea level, or 120 ft. above the ground surface.

The water company had exhaustive tests made of its wells in 1916, at which time it was recommended that the future increases in supply be derived from the 2,000-ft. depth. Acting on that recommendation, the water company let a contract for drilling one well to that depth.

The well was drilled by the rotary process. It consists of 915 ft. of 12-in., 934 ft. of 10-in., 44 ft. of 8-in. casing, and a 70-ft. strainer. The strainer consists of perforated well casing wound with brass gauze. The entire well was drilled and tested in 62 days, or at an average rate of nearly 34 ft. per day.

No rock has been encountered in any of the wells sunk thus far, and the holes are cased the entire distance. In wells of this depth and high flow the friction becomes important, and it was thought at the time of the report that the largest casing that could be successfully handled would be 8 in. for the top 1,390 ft., with 6 in. for the bottom 700 ft. It was estimated that such a well would yield about 840 gal. per minute free flow at the ground surface.

When the well was sunk, the contractor, who is one of the most experienced rotary well drillers, used the 12-in., 10-in. and 8-in. sizes, and secured a flow of 1,100 gal. per minute at the ground surface, the increase being due to the smaller friction losses in the larger casing.

The well has a static elevation 120 ft. above the ground, or 160 ft. above sealevel.

The contractor first ran a 10-in. fishtail drill down until he located a suitable foundation in tough blue clay for the 12-in. casing at a depth of 915 ft., then reamed the hole to 16-in. size, "slushed" the hole to insure its standing open, and inserted the 12-in. casing. This "slushing" is accomplished by pumping a mixture of clay to the bottom of the hole. As it passes upward outside of the pipe the clay particles seal up the sides of the well hole and by their cohesive properties preserve the well bore until the casing can be inserted and lowered to position.

The assembling and lowering of 915 ft. of 12-in. pipe required but 7½ hours. The casing was allowed four days for the sand to set around it before drilling for the 10-in. casing was started, in a manner similar to that described for the 12-in. casing. Similar methods were followed for the 8-in. casing and the 70-ft strainer.

The drilling penetrated 14 separate sand strata, each from 5 ft. to 194 ft. in depth, all of which were separated from those adjacent by thick layers of tough blue clay, which effectively cut off intercommunication of the water. Accordingly in each layer the pressure of the water would depend upon the elevation of the outcrop of the stratum in which it was found.

In the report made to the water company on additional water supply it was recommended that the future supply be taken from the 2,000 ft. depth, and it was thought that the sinking of one or two wells would make it possible to shut down the pumps and supply the city of 25,000 people during the night by the pressure from the wells. One well only was sunk in 1916, and for about two years it has discharged directly into the distribution system for about 6 hours during the night, delivering at a 300,000 gal. rate, and maintaining 30 lb. pressure. This practice has recently been discontinued on account of the pressure required for automatic sprinkler systems. If a second well was sunk, the two wells could furnish this amount of water with about 40 lb. pressure

Free Flow of New Well at Ground Surface Through an 8-in. Valve Partially Open.

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*Abstract of a paper presented at the recent meeting of the Illinois Section of the American Water Works Association.

on the mains. During the day the well discharges into the suctions of the pumps which are under pressure up to a 1,500,000 gal. rate.

The ground waters of this district vary in temperature and pressure directly with the depth. The variation in temperature is important upon the well yields, for the fine sand of Louisiana with water at 92° will transmit the water nearly 1¾ times as rapidly as the same kind of sand in Illinois with the temperature about 50°.

All wells in Louisiana do not furnish good water, although those near Baton Rouge yield a soft water of excellent quality. At some points salt wells have been found. The occurrence of salt water is, however, confined to small areas and is probably accounted for by a depression filled with salt water and without an outlet left during one of the recessions of the ocean in the formation of the lower Mississippi Valley and the Gulf Coast. This underground reservoir is under pressure from its northern outcrop and when tapped yields salt water.

A large number of wells have been drilled in and near Baton Rouge in addition to that of the water company, the most important being the group of 14 wells drilled by the Standard Oil Co. to supply cooling and condensing water for its oil refinery, which is now the largest in the world. These wells furnish nearly 5,000,000 gal. per day.

On account of the relatively low cost of sinking wells by the rotary process, a great many farmers have drilled wells to the 1,300-ft. depth, and have water piped under pressure for farm and household uses. In pre-war times a 6-in. well, 2,000 ft. deep, could be drilled, including casing, for $4,000.

One peculiar phenomenon was observed in testing the wells in and around Baton Rouge. The tests were made at the time when the highest water stages ever recorded on the Mississippi at this point were prevailing. All of the wells tested in the 900 ft. and 1,300 ft. strata had static elevations from 5 ft. to 15 ft. above those observed when the wells were drilled a year or a few years before, thus indicating that there is probably some connection between the river and the sand strata at some point between the outcrop and Baton Rouge.

It is probable that wells with still greater yield, higher temperature, and rising to still greater static elevations can be drilled near Baton Rouge, but, so far, 2,000 ft. is the greatest depth penetrated.

Methods for Improving Meter Department Efficiency

The Texas Power & Light Co. has adopted certain rules for the operation of its meter department, some of which will be of interest to water departments. A few of the rules follow:

Meters should be set not higher than 6½ ft. from the floor. Higher than this they cannot be considered accessible to the meter reader or the meterman in case a test is required.

A pass key must never be used for any place where there is furniture, with the exception of lodges, churches and picture shows.

In signing orders of any kind the employe doing so is to use his last name and never the initials only.

It will be the work of the office force to do all in its power to get the customer to come to the office to sign an application, and the work of the service men to get meters set in accessible places not exposed to the weather.

If a disconnect notice is written for a house which is to be reoccupied within a week, the distribution department should get the reading and open the switch, but leave the meter in the house. If the house is not to be occupied for some time, the meter should be brought in so that it may be cleaned and tested. Where the meter is left in a vacated house the meter card should say, "Meter left in," and it should also show the work order number when the meter is removed. It is preferable to disconnect at the pole where the meter is to be left in a house, except in apartment houses.

The reading on a disconnected meter should be left as it stands, rather than run the meter back to zero. If the customer objects, it is then explained that the company has a record of the reading in the office and knows exactly where to begin using it.

Test of Air Diffusers for Activated Sludge Process

Experiments with different varieties of diffusers used in connection with the activated sludge process were conducted at the University of Illinois. The tests formed the basis of a thesis prepared by F. L. Mickle under the supervision of Edward Bartow. An abstract of the thesis appears in a recently issued bulletin of the Division of State Water Supply, from which the notes following have been taken.

Reinforced concrete tanks located in the basement of the University of Illinois power house were remodeled for the experiments. Diffusers of perforated pipe, basswood blocks, and filtros plates were used. The tanks will be designated as "A," "B," "C," and "D."

Each tank is 3 ft. 2 in. square, inside measurement, and about 8 ft. 6 in. deep to the air diffuser. Each is equipped with an adjustable outlet made of 2-in. pipe connected with three lose joints. Each outlet was equipped with [illegible] chains so that at the end of the aeration periods the sludge could be allowed to settle and the outlet lowered to any desired depth for drawing out the effluent. A petcock is provided on each tank to relieve the air pressure while the tank is being drained and prevent air bubbles from rising and stirring up the sludge. Air was obtained from the University of Illinois supply and was measured by gas meters. The pressure was reduced by reducing gate and needle valves.

Tank A was equipped with a perforated pipe diffuser. The bottom of the tank is sloped from the center and sides at an angle of about 45°, thus forming two V-shaped channels of equal size 1 ft. in depth entirely across the tank. A perforated iron pipe with one end capped and the other end connected to the compressed air supply was laid in the bottom of each channel. The perforations were [illegible] in. in diameter spaced 2 in. apart and staggered at an angle of 15° from the top of the pipe.

The basswood blocks used for diffuser in tank B were furnished by the Milwaukee, Wis., Sewerage Commission, and many valuable suggestions regarding their installation were given by T. Chalkley Hatton, Chief Engineer, and Carl H. Nordell, Engineer of Designs. The blocks were 6 in. long, 2½ in. wide and ½ in. thick. They were held in a concrete container in a depression 2 ft. 3 in. long, 1 ft. [illegible] in. wide, ¾ in. deep at the edge, and 1¼ in. deep at the center. The surface of the depression was cast on a concave curve so that the tendency of the blocks on swelling would be to wedge themselves more firmly into position. There are [illegible] ridges ½ in. wide and ¼ in. high running crosswise of the container. The wooden blocks rest upon the ridges, leaving a ¼-in. air space below. These are connected by a central air channel 1 in. wide and ½ in. deep. Air enters through a pipe cast in the center of the container. Strips of galvanized iron were placed on edge between each two rows of blocks for reinforcement. Leaky joints were calked with oakum.

Tanks C and D each contained [illegible] filtros plates covering one-third of the floor area of the tank and forming the bottom of a central trough with sides sloping at an angle of 45°. Below the plates in each tank was an air space [illegible] in. deep. The plates were 12 in. square and 1½ in. thick. The plates in tank C were marked "fine" and on the manufacturing basis of dry rating they passed [illegible] cu. ft. of air per minute per square foot under a water pressure of [illegible] in. Tank D was equipped with plates marked "coarse" which on the same basis passed 12 cu. ft. of air per minute per square foot. When saturated with water and passing [illegible] cu. ft. of air per minute the plates marked "fine" showed a resistance on a water gage of from [illegible] to [illegible] in. and the plates marked "coarse" a resistance of from [illegible] to [illegible] in. The General Filtration Co. of Rochester, N. Y., furnished these plates.

Sewage was pumped from the [illegible] sewer just outside of the city limits. It is fresh, [illegible] domestic sewage containing no trade wastes. [illegible] used as a sample preservative and samples were stored in a refrigerator until analyzed. The [illegible] was unnecessary. The methods of analysis were those given in the [illegible] edition of the American Public Health Association's "Standard Methods for the Examination of Water and Sewage."

Three series of tests were made. There was no sludge present in any tank at the beginning of any series of tests. Results of tests are summarized in Tables I and II and the rate of aeration is given in Table III.

TABLE I—AVERAGE RESULTS OF ANALYSIS OF INFLUENTS AND EFFLUENTS OF TANKS.
(Parts per million.)

	Turbidity.					Ammonia nitrogen.					Nitrate and nitrite nitrogen.					Oxygen consumed.				
Series.	Sewage.	Effluents. A	B	C	D	Sewage.	Effluents. A	B	C	D	Sewage.	Effluents. A	B	C	D	Sewage.	Effluents. A	B	C	D
1.	375	90	..	67	59	34	27	..	28	29	.2	.1	...	.2	.2	82	38	..	34	50
2.	273	52	30	24	26	24	18	21	19	19	3.9	1.3	5.1	4.4	6.3	57	23	17	14	15
3.	274	13	10	11	11	21	20	19	6	6	2.5	1.7	1.9	12.6	13.6	52	21	22	20	19
1*	391	98	..	42	38	34	29	..	30	30	.1	.1	...	.4	.4	85	31	..	20	21
2*	153	18	7	5	5	14	11	14	13	13	6.6	2.2	9.6	8.0	11.8	42	17	12	10	11
3*	283	5	5	5	5	24	24	23	0	0	1.7	.3	.1	17.8	19.4	55	32	26	25	10

*Results after activated sludge was formed.
A. Tank with perforated pipe diffuser.
B. Tank with basswood blocks diffuser.
C. Tank with fine filtros plates diffuser.
D. Tank with coarse filtros plates diffuser.

TABLE II.—PERCENTAGE REMOVAL OF TURBIDITY, AMMONIA NITROGEN AND OXYGEN-CONSUMING CAPACITY

Series.	Period 1917.	Turbidity. Effluents. A	B	C	D	Ammonia nitrogen. Effluents. A	B	C	D	Oxygen consumed. Effluents. A	B	C	D
1. Reduction..	Feb. 2	75	..	82	85	19	..	16	14	53	..	59	63
2. Reduction..	Mar. 1-20	81	89	91	90	26	13	21	21	60	70	75	74
3. Reduction..	Mar. 27-Apr. 30	95	96	96	96	5	10	71	71	60	58	62	63
1. Reduction*		76	..	88	90	13	..	10	7	63	..	75	75
2. Reduction*		88	95	97	97	21	0	7	7	60	71	76	74
3. Reduction*		98	98	98	98	0	4	100	100	41	53	51	70

*Results after activated sludge was formed.

In the first series of tests extending over a period of 15 days filtros plates and perforated pipes were used. About 19,000 gal. of sewage was treated in each tank with an average of 2.5 cu. ft. of free air per gallon of sewage. In the second series of tests extending over a period of 20 days all four tanks were in operation. About 17,000 gal. of sewage was treated in each tank with an average of 1.8 cu. ft. of air per gallon of sewage. Measured in terms of removal of turbidity, removal of oxygen-consuming capacity and the production of nitrate nitrogen, the purification was best in the tanks containing filtros plates, and in Series 2 the tank with wooden blocks gave better results than the tank with perforated pipes. Measured in terms of removal of ammonia nitrogen the purification was best in the tank with the perforated pipes. The third series of tests, which lasted 35 days, was the most satisfactory. About 30,000 gal. of sewage was treated in each tank with an average of 3.2 cu. ft. of free air per gallon of sewage. No accurate comparison of the sludge accumulation at the end of the series could be made, for owing to the length of the run the excess of accumulated sludge was wasted at times. Measured in terms of removal of ammonia nitrogen and in production of nitrate nitrogen the tanks with filtros plates were decidedly superior. Ammonia nitrogen was entirely removed in the tanks with filtros plates after 17 days. Owing to rain, nitrate nitrogen was present in the raw sewage during the early part of the series, and continued to increase in the tanks containing filtros plates, reaching about 25 parts per million. Practically all of the nitrate nitrogen disappeared from the other tanks. The poor results from the tank with wooden blocks were probably caused by the development of a hole which prevented the formation of finely divided bubbles.

The stability to methylene blue was tested on and after the 11th day. All effluents from the tanks containing filtros plates were stable for 10 days at 20° C. The majority of the effluents from the other tanks was unstable. Nearly 30,000 gal. of sewage was treated in each tank with 3.2 cu. ft. of free air per gallon. A summary of operating data is given in Table III.

Conclusions.—The results of this investigation justified the following conclusions:

Filtros plates proved the most efficient of the three types of diffusers, as evidenced by the analytical data. They gave sludge that settled rapidly leaving clear and stable effluents.

The degree of porosity of the filtros plates made no apparent difference, for the coarse and the fine grades of plates gave practically the same results.

The wood-block diffusers gave unstable effluents in the majority of the samples. With these effluents the chemical results were not as satisfactory as with those from the filtros plates.

The wooden blocks were very difficult to install and even in the short time they were in service they showed evidence of marked deterioration. Until these defects can be remedied their installation in working-scale plants is impracticable.

The perforated pipes gave the least satisfactory chemical results. The majority of the effluents were unstable.

TABLE III.—AMOUNT OF AIR USED.

	Cubic feet of free air used per gallon of sewage.			
Series.	A	B	C	D
1.	2.5	...	2.5	2 3
2.	1.8	1.7	1.9	1.8
3.	3.2	3.1	*4.5	3.2

*Figure high due to leak which developed in air line. The actual amount of air supplied was about the same as supplied to the other tanks in this series.

Clogging of the diffusers during the period covered by these experiments was not sufficient to have practical significance.

Method of Constructing Tile Drain Through Sand

By L. U. MARTIN.

During the summer of 1916, County Ditch 17 was started. This tile system included about 2 miles of main ditch and about as much more in branches. The tile ranged in size from 26 in. to 5 in. When the main ditch was at Station 10 sand and gravel were encountered at a depth of about 3 ft. below the peat and mud. This sand contained so much water that cribbing had to be used, although the tile were bottomed only 5 ft. below the surface. By the time station 20 was reached, which had a depth of 8 ft., tight cribbing had to be used and even with that it was practically impossible to make any progress, as the water and sand flowed in so fast. At about this point we struck a bed of blue clay below the sand and the bottom was found to run from a few inches to 1½ ft. into this clay. At the line of contact between the sand and the clay the flow of water would come through any little crack in the cribbing and wash in sand faster than it could be thrown out. By the time Station 27 was reached progress was at a standstill and the contractor had spent three times the bid price of the station in going 85 ft. This was alright for the contractor who was protected by a 20 per cent cost plus clause in his contract in case of sand, but was plainly out of question for the ditch owners, as the assessed benefits would not permit of more than 12 per cent overrun on the bid price.

Test pits were put down ahead of the work and the same conditions were found to prevail for the next 50 stations, with a depth varying from 10 to 17 ft. We now stopped all attempts at laying tile and started to top these 50 stations. By the time this was accomplished, 4 to 5 ft. deep and 3½ ft. wide, cold weather had set in. A few inches of straw were placed in the bottom of the ditch and was left until the walls were frozen. We then took out another spading back for a few stations, and as the walls froze we kept carrying it down to grade and laying tile. It was found practical to work only a small crew and not to open too much at a time, as the last two spadings froze rather slowly, and snow would blow in and bother if too much was opened ahead. Working in this way we found that a great deal of the cribbing could be done away with owing to the fact that the flow of water greatly diminished in the winter and also the frozen banks did not cave readily even if undermined some. It was slow work and greatly delayed the completion of the ditch, but the work was accomplished at the contract price and the contractor made good wages out of the job. The ditch came out at the assessed value of the benefits so its completion was made possible.

Drain Made of Portable Concrete Sections.—A sectional concrete ditch bottom, devised by one of the Panama Canal sanitary inspectors, has been a valuable aid in antimalarial work in the Canal Zone during the period of over a year in which it has been in use. A section of the drain is 30 in. long by 10 in. inside diameter. Each section has a bell joint which is provided with a male and female union. The joints are held together by a ½-in. steel plug, which stiffens the segments until they have been properly backfilled and leveled and the cement poured into the joints has hardened. The proportions of cement, sand, and gravel used in making the sections are the same as in ordinary block construction. The sections are reinforced with chicken wire. Each segment weighs 100 lb. The size of the segment can be varied. Key walls can be added in "green" concrete and curved and angle sections are easily constructed.

Reduction of Water Waste by Means of Pitometer Servey and Constant Inspection*

By GEORGE C. ANDREWS,
Water Commissioner of Buffalo, N. Y.

In 1897 the Buffalo Common Council decided it more advantageous to its citizens to install more pumps and give practically an unlimited supply of water, than to control consumption by means of meters. It is hardly necessary to add that this decision was made contrary to sound engineering advice. It would be interesting to speculate on what that decision has cost the citizens of Buffalo in the past 22 years. Suffice it to say that in 1903 the Bureau of Water bas a bonded debt of $3,699,382, while it was $12,141,524 in 1917. From that date until 1917 it was a race between the unchecked waste both in mains and in houses and the pumps.

In 1903 there was one pumping station with a daily capacity of 183,000,000 gal. In 1917 there were two pumping stations with a combined daily capacity of 330,000,000 gal. Coincident with the increased pumping capacity large distributing mains were laid. During this period the per capita consumption had ranged between 302 and 339 gal. per day. Of this practically 100 gal. was for industrial use.

In 1916 the city government was altered and a commission of five men elected to govern the city. Their platform was an economical and efficient city government and one of the early efforts was an investigation as to means to reduce city water consumption. As all water used must be pumped from Lake Erie against a head of 140 to 204 ft., a reduction in pumpage would make an immense saving in coal used for fuel. Various methods were considered and in the spring of 1917 it was decided to have a pitometer survey made of a small section of the city with the idea of covering the whole city later should this section show satisfactory results. The question of metering was considered but rejected on various grounds, some of which were: Popular local prejudice against metering, length of time to completely meter city, there being over 76,000 unmetered and active services, while the pitometer method promised early results; extensive changes in plumbing required should meters be installed in many of the poorer types of dwellings, heavy initial investment required for meters.

To facilitate the work and also that definite records could be obtained of water consumption in different points, the city was divided into 10 sections, none of which were similar in character and work completed by sections.

To make the survey, an engineer in charge and four assistants were employed. Three trucks with gangs of four men were constantly engaged and one clerk assigned to this work to keep the records. Twelve of the regular city inspectors made the house-to-house inspections. Later, as more of the city was covered, 20 temporary inspectors were engaged.

One of the assistant engineers made the district measurements and two were constantly engaged on sub-division. One assistant engineer tested the meters and fire lines. During the winter months two men worked in the office. The inspections for house waste is of great value, and a large percentage of the total waste eliminated is directly due to inspections. However, proper control must be exercised or the results will be indifferent. From 1906 until 1915, the department employed men to stop house waste, but had no control over same by means of district measurements. During this period the per capita consumption was practically stationary, although the annual consumption increased.

As the sub-divisions showed waste in practically every block, a system of inspection records was developed. Inspectors worked in pairs and a report on every house and service was made. Where leaks were discovered, a repair notice was left. Two weeks later a second inspection was made of all places where notice to repair was served. If repairs had not been made at that time a second repair notice was left and a re-inspection made three days later, at which time water was turned off, unless all plumbing was in good shape. The years of unlimited use and waste of water had rendered most people indifferent to the condition of the plumbing in their houses and at first numerous complaints were made at the so-called arbitrary ruling of the Bureau. However, these soon ceased and as the purpose of the survey became apparent and in the majority of cases splendid co-operation was secured.

The inspectors tested, first the house fixtures and then if these were O.K., tested with the aquaphone at the curb box for service leaks. If house waste was found the stopcock at the house was closed before testing for service leaks. On their inspection report blanks leaks were listed as service, faucet, toilet, etc., and a notice showing the nature of the leak served. A record of the number of people on each service was also reported. After the house inspection in a district was completed, the pitometer was again used to record the flow in different blocks in the sub-division. Where the night rate was still excessive, investigation for underground leaks was started. The determination of the underground leaks is largely a matter of skill, judgment and experience. By sub-dividing by blocks the leak can be located as to block, but then the operator must find same by skill and judgment. If service pipes and boxes have been installed the aquaphone can give one the approximate location and by driving a steel rod to the main the leak can be closely located. In only a few cases was it necessary to excavate more than one hole to find the leak.

As work was completed in each division a permanent map was filled in the office, showing gaging points for measurements and valves on boundary points. On this map is recorded date of first measurement 24 hour consumption and minimum night rate, and same record measurement. It is the intent of the Bureau of Water to continue the pitometer work as a pecial department and regular measurements will be taken at varied intervals, and these maps will facilitate the work greatly. All inspectiors' reports are filed by streets and can be instantly referred to. As soon as a section was completed a full report on same was submitted by the engineer in charge. This report gave a general summary of the work with certain specific recommendations to meet the conditions for the sections. These reports are filed so as to be available for future reference.

The report for Section 4 showed as follows:

Total flow before inspection per 24 hours	17,[illegible] gal.
Minimum night rate	14,912,[illegible] gal.
Per cent of night rate to total flow	86.2 per cent

Inspections of all buildings on this section showed 3,444 leaky fixtures, divided as follows: Faucets, 1,064; toilets, 2,380.

It also disclosed 280 leaky services, which were repaired by the owners: Eight unfinished supplies which were discharging into the sewer were dug up and plugged. Also one broken 6-in. main was uncovered and repaired.

After the house inspection and underground work was completed a remeasurement was taken with the following results: Reduction in daily consumption 3,780,000 gal.; reduction in night rate, 3,910,000 gal.

On account of the desire to reduce the pumpage as quickly as possible, so as to conserve coal as a war measure, no intensive work was attempted and the city surveyed as rapidly as consistent with good work. It is highly probable that the results in this section could have been bettered had more time been devoted to it. However, by extending the work rapidly large leaks in other districts were detected and stopped in the time which might have been devoted to more intensive work in this section. It is expected that the work to be done in this section this summer will materially better the above result.

Our first section was surveyed in 1917 and this year remeasurements have been taken. These show that there is a more or less gradual return of the waste first eliminated, depending wholly on the character of dwellings. In all sections the consumption was less than it was two years ago at the time of the first measurement. In one case the result showed only 10 per cent increase over the first measurement. I estimate that effects of the result of the survey will be from one to three years as far as house waste is concerned. All underground leaks stopped are permanent saving.

In the sections completed the house waste stopped is estimated at 18,000,000 gal., while the underground waste stopped was 1[illegible],000,000 gal. by actual measurement.

It is our intention to measure and [illegible] city in two years and to completely inspect as often. Of course measurements and inspections will be made oftener in the sections where waste is greatest. To more fully control waste in these sections meters will be placed gradually.

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*Abstract of a paper presented at the last annual convention of the American Waterworks Association.

Nine-tenths of the city has now been covered by the survey with the following results:

33,278 leaky fixtures reported and repaired.
1,860 leaky services reported and repaired.
52 unfinished supplies found wasting 3,487,000 gal. per day.
Broken mains and leaky joints wasting 4,376,000 gal. per day found and repaired.

The services, broken mains, unfinished supplies and leaky joints repaired account for 12,000,000 gal. waste per day permanently stopped.

The pumpage has been reduced except in times of extremely hot or cold weather to less than 125,000,000 gal. per day, as compared to over 160,000,000 gal. per day in 1917. Figuring the cost of pumping at $6.24 per 1,000,000 gal., the average cost for the last three years, the annual saving is $68,328. Against this is the estimated charge of $25,000 per year to maintain the Pitometer Division of the Bureau.

To date the survey has cost $96,931, much of which represents permanent investment in equipment and records, or for professional services.

Including the pay of temporary inspectors, who will be employed each spring, it is estimated that the annual cost of continuing the work will be $25,000 per year.

Cost of Machine Trenching for Sewer Construction

Machine trenching in the construction of the Stanley St. sewer at San Francisco cost about one-fifth as much as by hand trenching. This sewer provides an outlet for the westerly portion of the Oceanview district. Starting at Orizaba and Palmetto Sts., and running to Orizaba and Sagamore Sts., is a 21-inch iron-stone pipe. From the last named intersection to Stanley St. and west erly on Stanley to Russell St., the sewer is of reinforced concrete, 2 ft. by 3 ft. inside dimensions. At the corner of Stanley St. and Ramell St., the structurt is enlarged—the inside dimensions are increased to 2 ft. 6 in. by 3 ft. 9 in.

Continuing along Stanley St., the sewer crosses Stanley St. creek. in a concrete culvert supported on concrete piers, and extends to an overflow at St. Charles Av., so designed that when the 2 ft. 6 in. by 3 ft. 9 in. sewer is flowing at or near full capacity, the greater portion of the storm water and diluted sewage will pass over a weir into the Stanley St. creek; thence it will be conveyed across the Merced lands, through an existing wooden flume and through a tunnel direct to the ocean. Undiluted sewage, however, passes under the Junipero Serra Blvd. through a cast-iron pipe, which continues across the Merced lands to Sloat Blvd., where it discharges into the lower Sunset sewer, whose outlet is at Mile Rock.

During construction, where the contour of the ground permitted, a ditching machine was used, which not only produced cheaply a uniform trench in which to lay the heavy cast-iron pipe but speeded the completion and earlier use of the entire system.

The following costs to the contractor of some of the items —office overhead and the necessary insurance and bond not included are taken from the report of M. M. O'Shaughnessy, City Engineer, for the fiscal year ending June 30, 1918:

15 in. iron-stone pipe, per foot	$ 1.65
21 in. iron-stone pipe, per foot	1.79
2x3 reinforced concrete sewer, per foot	3.31
2 ft. 6 in. x 3 ft. 9 in. reinforced concrete sewer, per foot	3.51
Brick manholes, each	40.50
Overflow structure	465.65

Trench excavation for the cast-iron pipe was in stiff sandy clay. The cost of that portion of the work done by hand was $0.91 per cu. yd.; the cost by machine was $0.18 per cu. yd.. including a fixed charge of $32 per day for the use of the machine.

The 18-in. cast-iron pipe cost $0.228 per foot to lay, yarn, pour and calk the joints.

The prevailing rate of labor during construction was $3.00 per day.

Conclusions of Am. W. W. Assn. Committee on Private Fire Protection Service

Private fire protection service has been a subject of discussion between the water purveyor and the insurance interests for years. The Proceedings of both the American and New England Water Works Associations contain many pages devoted to this topic, and the interest displayed is evidence of the concern which this class of service has caused the water works superintendent. A number of different questions are involved which divide themselves naturally into two classes, physical and fiscal. The physical questions relate to the manner of installation, the fiscal questions to the distribution of the cost of installation and proper charges for service. At the annual convention of the American Waterworks Association, last month, the Committee of the Association, consisting of Nicholas S. Hill, Jr., Chairman, George G. Earl, Frank C. Jordan and Walter E. Miller, submitted its final report on this subject. The more important questions considered by the Committee, together with their finding and recommendations are as follows:

Physical Questions.

(1) Shall water for domestic and manufacturing uses be furnished through the same service pipe with water for private fire protection equipment?

Water for domestic or commercial uses should be furnished through the same service pipe with water for private fire protection equipment for certain classes of consumers only. When a combined service for fire protection and other uses is allowed, a meter which will register all flows from the smallest to the largest, and of equal accuracy to the ordinary domestic and commercial meters, should be installed on the connection. In no case should a combined connection for fire service and domestic, commercial or manufacturing uses be allowed for mills, factories, large industrial establishments. or railroad terminals and yards.

(2) How shall the water purveyor be protected so as to prevent the intentional or unintentional use or waste of water through such connections?

No fire service connection should be installed without a fire service meter unless a system similar or equivalent to the Bond-Alarm-Inspection System is adopted.

(3) How shall private fire service pipes be controlled where they enter buildings or private property so that in case of the breaking of the inside pipe, or of the service pipe, water may be shut off and bleeding of the water system prevented?

No private fire service connection should be installed without careful and adequate provision for properly located control valves equipped with indicator posts.

In congested districts, where property values are high and the finding of a safe and accessible location for the control valve is difficult, the installation of automatic or distant control is recommended as soon as a suitable device for this purpose is developed.

(4) What limit should be placed upon the size of fire service connections?

No service connection with a capacity in excess of 50 per cent of the water main supplying it should be installed. All risks requiring more than 50 per cent of the main capacity should be required to provide a supplemental water supply by storing water in elevated tanks or the equivalent.

(5) What means shall be adopted to prevent the pollution of a public water supply through a private fire protection service when an independent water system is also connected with the fire protection system?

Where an independent supply is used for private fire protection, the fire service connection from the public mains should discharge either into a cistern or elevated tank at or above the flow line and the protected property required to take water for the fire protection equipment from the cistern or tank to preclude the possibility of back flow.

When such an arrangement is not possible of attainment double check valves should be installed with proper means for insupection and testing. Such valves should be regularly and systematically inspected, and reports filed as to their condition.

Fiscal Questions.

(6) By whom should the cost of installing the private fire service connections and accessories be borne?

When the utility lays the service connections to the curb and owns and controls them, the rates should be made to pay interest and depreciation and the maintenance cost of such services.

With a rational system of rates and charges, there is no reason for making any distinction between private fire service connections and any other service connections. The committee is, therefore, of the opinion that the water utility should pay the cost of installing the private fire service connection as far as the property line and that the charge for private fire service should be sufficient to cover interest, sinking fund charges and maintenance on the installation.

So far as the cost of installing the accessories, including control valves, check valves and alarm valve or meter is concerned, these devices should be owned and controlled by the water utility and, therefore, should be paid for by it and the fire service rate so fixed as to include a fair allowance for repairs and maintenance, and a reasonable return on these elements, as well as on the service connection proper.

(7) Shall a charge be made for private fire protection service?

The service required of a water utility is of two classes:

1. Readiness to serve a large quantity of water at irregular and indeterminate intervals whenever called upon.
2. A constant supply of water with comparatively slight variation in the amounts called for.

The private fire protection consumer falls into the first class. What he requires is a connection of large capacity through which a small amount of water is ordinarily taken, but which may be utilized to full capacity at infrequent intervals. His needs are distinct from those of the ordinary domestic consumer who requires a quantity of water continuously and substantially proportional to the capacity of his service connections. In the case of one we have capacity cost, in the other production cost. Since the cost of service should not be shifted from one source to another in the rates, it follows that the consumer who requires the utility to incur capacity costs should not put the burden of paying for them upon the consumer who does not want capacity but wants water. Under the circumstances, therefore, the committee has no choice but to recommend that a charge for private fire service connections be made.

(8) How should the charge for private fire protection be determined?

The principal steps in the establishment of a system of rates may be outlined as follows:

	Per cent.
A. Subdivide the total required revenue between water service revenue and miscellaneous receipts:	
Miscellaneous receipts	
Total water service revenue	
B. Subdivide the total water service revenue between fire service and general water service revenue:	
Fire service revenue	5 to 50
General water service revenue	95 to 50
Total water service revenue	100 to 100
C. Subdivide general water service between revenue from fixed service charges and revenue from proportional service charges:	
Fixed service charges	20 to 40
Proportional service charges	80 to 60
Total general water service revenue	100 to 100
D. Subdivide fixed service revenue between capacity of demand cost and service or customer cost:	
Capacity or demand cost	20 to 50
Service or customer cost	80 to 50
Total	100 to 100

Having ascertained the proper amounts to be collected from public fire protection and from general water service, the next step is to deduct the revenue derived from public fire protection from the total water service revenue, and apportion the remainder, or the general water service revenue, between revenue to be derived fom fixed service charges and from proportional service charges. The propotional charge covers the cost of producing and delivering water for the normal service requirements, and includes collecting and storing, pumping, filtering, transporting and distributing. Since the proportional charge varies with the quantity of water taken, the basis of charge should be so much per 100 cu. ft., per 1000 cu. ft., or per 1000 gal.

The capacity costs are the costs chargeable to the excess plant made necessary to meet the contractual obligations of the company to furnish the maximum demand which the water consumer may make. The total fixed service charge for domestic, commercial, industrial and public uses other than fire, which is the sum of the capacity and consumer cost, should be levied as a fixed annual amount to be paid quarterly whether water is taken or not.

By deducting the revenue from the fixed service charges from the total revenue to be derived from general water service, the amount to be derived from proportional charges for water used may be ascertained. When this is done ascertain the total net pumpage, that is, the total pumpage less water unaccounted for due to pump slippage, leakage in mains, etc., and divide the total revenue to be derived from proportional changes by the total net water delivered to ascertain the rate per unit of water sold.

Bill Before Congress for Federal Department of Public Works

Far reaching changes in the executive machinery of the Federal Government are proposed in bills introduced June 25, in each house of Congress. The federal Department of the Interior will become the Department of Public Works, if the legislation proposed is enacted. The main idea is to assemble all engineering activities of the Government in one department.

Such bureaus of the Interior Department as are non-engineering in character are to be placed under the jurisdiction of appropriate departments, while engineering bureaus from other departments are to be included in the Department of Public Works. The bill proposes that the Patent Office be removed from the Interior Department and placed under the Department of Commerce. The Bureau of Pensions is assigned to the Department of Treasury. The Bureau of Education goes to the Labor Department. The Bureau of Indian Affairs also is transferred to the Department of Labor, with the proviso that the engineering and construction work and the land and mineral surveys now performed under the direction of the Bureau of Indian Affairs are to be prosecuted under the Department of Public Works.

On the other hand, the Department of Public Works is slated to absorb the Supervising Architects Office of the Treasury Department, the Construction Division, River and Harbor Improvements, Mississippi River Commission, and California Debris Commission of the War Department, the Bureau of Standards and the Coast and Geodetic Survey of the Department of Commerce, the Bureau of Public Roads and the Forest Service of the Department of Agriculture.

The bill provides that the Secretary of Public Works shall by training and experience be qualified to administer the affairs of the Department and to evaluate the technical principles and operations involved in the work thereof. The measure excepts from the foregoing provision the Cabinet officer who is at the head of the Department at the time of the passage of the bill.

Four Assistant Secretaries, each to be paid $7,500 per annum, are provided. One Assistant Secretary is to have administrative jurisdiction over all matters of engineering design and construction. Another is to have charge of architectural design and construction. The third is to have jurisdiction over all scientific work and surveys, while the fourth Assistant Secretary is to be in immediate charge of all land and legal matters. The Assistant Secretaries are charged with the duty of co-ordinating and bringing into efficient relationship all the activities of the department so that it may be harmoniously and efficiently administered.

An important feature of the bill is the provision that engineer officers of the U. S. Army detailed on non-military work are to be assigned by the Secretary of War to like duties under the new department, for not over two years. This enables the Secretary of Public Works to make gradual transfer of improvements and instrumentalities to civil administration without detriment to public interest. Members of the Corps of Engineers may, under the direction of the Secretary of Public Works, be detailed by the Secretary of War to temporary duty in the new department for such instruction, training and experience as is desired.

The bill, which was introduced in the Senate by Senator Wesley L. Jones, of Washington, and in the House by Representative Frank C. Reavis of Nebraska,

Conclusions of International Joint Commission on Pollution of Boundary Waters

That pollution of boundary waters between the United States and Canada can be prevented or remedied without imposing an unreasonable burden upon the offending communities is one of the conclusions of the International Joint Commission which has been studying this question since 1912. The final report of the Commission was made public recently. The following is a summary of the conclusions the Commission has arrived at, and of the recommendations it submits to the governments of the United States and the Dominion of Canada:

The Great Lakes beyond their shore waters and their polluted areas at the mouths of the rivers which flow into them, are, except so far as they are affected by vessel pollution, in a state of almost absolute purity. With the exception of these pure areas, the entire stretch of boundary waters, including Rainy River, St. Mary's River, St. Clair River, Detroit River, Niagara River, St. Lawrence River from Lake Ontario to Cornwall, and the St. John River from Grand Falls to Edmundston, New Brunswick, is polluted to an extent which renders the water in its unpurified state unfit for drinking purposes. This pollution has its origin chiefly in the sewage and storm flows from the riparian cities and towns and the sewage from vessels. It is very intense along the shores of the Detroit and Niagara Rivers and in the contaminated areas in the Lakes. Throughout the whole length of the boundary waters where sewage is discharged from the sewerage works of cities and towns the pollution is most concentrated in the shore waters on the side of the boundary on which it originates. These shore waters, besides being in places unsightly, malodorous and absolutely unfit for domestic purposes, are a source of serious danger to summer residents, bathers and others who frequent the localities So foul are they in many places that municipal ordinances have been passed prohibiting bathing in them.

In the Detroit and Niagara Rivers conditions exist which imperil the health and welfare of the citizens of both countries in direct contravention of the treaty. This is true, though in a less marked degree, of the Rainy and St. John Rivers.

In the St. Mary's, St. Clair and St. Lawrence Rivers pollution exists which is in substantial contravention of the spirit of the treaty, and unless these conditions are improved, and the rivers placed under the control of competent authority, the resulting injury will be much more pronounced as population increases.

Vessel pollution in certain parts of boundary waters exists to an extent which causes substantial injury to health and property. It is derived from two sources, sewage waste from vessels and "water ballast" which is taken in by lake vessels at their ports of departure and emptied into these waters at or near their ports of destination. Vessel pollution is distinctly traceable in boundary waters in lanes and channels which vessels traverse in navigating them, their waters being thereby rendered unfit for drinking purposes.

In some cases sawmill and other mill waste, garbage, offal, carcases and other refuse matters are discharged into boundary waters. This practice results generally in a contravention of the treaty.

It is feasible and practicable, without imposing an unreasonable burden upon the offending communities, to prevent or remedy pollution, both in the case of boundary waters and waters crossing the boundary.

(a) In the case of city sewage, this can best be accomplished by the installation of suitable collecting and treatment works, the latter having special reference to the removal of bacteria and matters in suspension.

(b) In the case of vessel sewage, a feasible and inexpensive remedy lies in the employment of recognized methods of disinfection before it is discharged. In the case of water ballast suitable rules and regulations should be prescribed with a view of protecting the water intakes.

(c) The discharge of garbage and sawmill waste into boundary waters should be prohibited, and industrial and other wastes, which are causing appreciable injury, should be discharged subject to such restrictions as may be prescribed.

In order to remedy and prevent the pollution of boundary waters and to render them sanitary and suitable for domestic purposes and other uses, and to secure adequate protection and development of all interests involved on both sides of the boundary, and to fulfill the obligations of the treaty, it is advisable to confer upon the International Joint Commission ample jurisdiction to regulate and prohibit this pollution of boundary waters and waters crossing the boundary.

Use of Cement Joints for Cast Iron Water and Gas Mains

In the construction (just completed) of the United States Housing Corporation Project No. 581, at Vallejo, Calif., for the Mare Island Navy Yard, a very successful use was made of cement joints in laying the cast iron water and gas mains.

The methods of construction used and results obtained are interesting.

Oakum or jute not being regarded as satisfactory to use with cement it was decided to use hemp rope, and discarded slings made from ½-in. and ¾-in. tarred rope were obtained from Mare Island Navy Yard. These were old, dried out and very stiff, and after being cut into required lengths for use were unstranded and the strands loosely retwisted and rolled by hand, the thickness depending on the size of joint to be caulked.

It was considered that upon the use of this particular type of packing rested the success of the work, since this—rather than the cement binder—was relied upon as the water and gas-tight element in the joint.

Great care was taken to see that all pipes as laid were solidly blocked in order that there would be no movement of the pipe line during and after making the cement joints and earth was tamped around and over the pipes between joints.

One and sometimes two strands of the retwisted hemp rope was inserted in the bell of the pipe and rammed in hard by caulking. A mixture of cement and sand, in the proportion of 2 parts cement to 1 part clean sharp sand with enough water added to make a dry paste, which when balled and squeezed in the hand would barely exude moisture, was then inserted in the bell, pressed in first by hand until the bell was about half filled, and then caulked as a lead joint would be caulked, until the caulking tool would barely penetrate the cement and the joint would ring. More of the cement paste was then inserted and the caulking repeated, leaving the joint filled to within ½ in. of the face of the bell. A strand of the retwisted hemp rope was then laid around the bell and this caulked in flush with the face of the bell. The joint was then wiped with cement paste containing sufficient moisture to mould and the same beveled off.

Each joint after making was kept wet, by covering with pieces of old sacks, for at least 36 hours, after which the pipe line was slowly filled and allowed to stand under normal pressure which was never greater than 70 lb., for at least two days, before the test pressure was put on.

Two thousand lin. ft. of 10-in. water main and 400 ft. of 8-in., 6-in and 4-in. pipe were included in the first test and 50 per cent of the joints leaked after subjecting them to the normal pressure. These leaks ranged from a slight sweating to a steady drip which filled the bell holes and covered the pipe. During the following three days most of the leaks stopped and it was decided to cover and backfill the whole pipe line, as the character of the ground was such that any leak would come to the surface, and let the pipe line remain under normal pressure for a week or two before putting on the test pressure of 125 lb. The dry hemp rope undoubtedly absorbed moisture and swelled, thereby stopping all leakage. All leaky joints took up with two exceptions both of which upon being cut out and examined were found to have been very carelessly made. These were remade and the line when tested showed no leakage.

As the work progressed and the workmen, who were unskilled Italian laborers, became more proficient the work was not only speeded up but better results obtained.

A total of 20,770 lin. ft. of 4-in., 6-in., 8-in., 10-in. and 12-in. cast iron pipe was laid on this project for water and gas distribution and only six defective joints had to be cut out and remade. When the pipe line could be drained the joint was remade with cement, but a few joints were cut out and remade with lead wool in order not to delay progress.

As it was necessary to pave the streets immediately upon completion of the sewer, water and gas mains and services, the pipe lines were subjected to a severe test on account of the heavy teaming and heavy steam roller working on the sub-grade, but not a single leak developed. The paving was completed in January and the first leak has yet to develop.

As far as could be ascertained from observation and cost records kept, the labor cost using cement joints should be slightly less than for lead joints.

Mr. Stephen E. Kieffer, M. Am. Soc. C. E., of San Francisco, Calif., was Project Engineer for the United States Housing Corporation, and Mr. Philip Schuyler, Assoc. M. Am. Soc. C. E., was Assistant Engineer in direct charge of construction.

Future Prices and Present Needs for Waterworks Improvements

Probable future price tendencies for water works labor and material were summarized by Mr. Leonard Metcalf, Consulting Engineer, Boston, Mass., in his paper presented June 10 at the Buffalo convention of the American Water Works Association. His statement follows:

Future Prices.—With respect to unskilled labor—while it is possible that there may be come reduction in its cost during the coming season, no marked change is to be looked for; and with respect to the rates paid to water works employes, it is believed that the prices now paid are likely to continue in most cases, and to increase rather than decrease in the remaining cases.

Unless Bolshevism runs its course in this country, or industrial depression should follow the war—neither of which seem likely—an active demand for labor is to be looked for in the near future. It is to be remembered that despite the war, the population of this country has been increasing at a rapid rate. Immigration has been at a standstill and in the light of home demand for labor abroad, does not seem likely to be active for some time to come. Many employers, contractors and labor leaders believe that in the not distant future this country is sure to feel the competition for available labor and that this will stimulate yet higher wage scales. Past experience following wars indicates that later on reaction may come, and business depression be felt for a time, but such influence is not likely to be of long duration or to affect permanently the upward tendencies.

With respect to materials of construction, there is greater hope for relief. Nevertheless, no substantial reduction in the price of cast iron pipe, valves and hydrants seems likely for the present year, and but a gradual reduction is to be looked for in the future. In spite of the increased facilities for production, the labor, transportation and money conditions involved seem likely to make themselves adversely felt for some time, and the losses resulting from the war, permanently.

The materials of operation, coal, fuel, oil, and chemicals—do not appear likely to decline markedly in cost, and such tendency toward decrease as there may be, will probably cause the making of short-time, rather than long-time, contracts for such supplies.

Declining Service.—Capital has not been available for many desirable extensions during the war period. The added financial burden of such new construction as has had to be undertaken, has in many cases been substantial. The increase in operating costs and taxes has been tremendous.

The structural plans of water works properties have not been maintained generally in normal condition during the war. Such has been the experience abroad, as well as in the United States. The obtaining of needed added supplies, drainage areas and water rights, the enlargement of the mechanical, pumping and boiler plants, the extension and reinforcement of supply and distribution pipe systems, and the making of normal betterments of various kinds, have been deferred, in order to conserve the country's financial resources, for war purposes.

It will probably be admitted generally, by water works men, that the war has enforced upon water works, as upon other public utilities, a declining service.

The Future.—The conclusion to be drawn from the present physical and financial condition of water works in the United States seems clearly to be that necessary improvements should go forward as rapidly as possible. It is desirable to restore public confidence and further the Government's wise wish to give employment to idle labor. More important yet, improvements are seriously needed to restore our normal high standard of water service to adequately safeguard the public health.

While city officials and water works men are hesitating, the large manufacturing interests, dominated by shrewd, far sighted business men, are going ahead with their construction work, with their plant extensions and housing projects, confident that postponement will at best offset increased cost in small measure, will probably involve loss in service or profit far exceeding any saving in construction cost, and at worst will involve yet higher costs, coupled with these losses and with increasing difficulties due to a vanishing labor surplus.

The public is far more vitally interested in thoroughly good and adequate present service than in any probable saving to be effected by delaying construction to a later date, in anticipation of further more or less problematical decline in costs.

Rainfall Intensity Curves for Buffalo, N. Y.

Studies have been made by the Bureau of Engineering of Buffalo, N. Y., from data furnished by the United States Weather Bureau on the subject of rainfall intensity. The results which are contained in the recently published report on the Pollution of International Boundary Waters indicate a rainfall intensity curve of the following form

$$I = \frac{11}{T^{0.41}} \qquad \begin{array}{l} I = \text{Intensity in inches per hour} \\ T = \text{Time in minutes} \end{array}$$

as inclusive of all but three storms in a period of [illegible] years and with the intensities of these excluded storms falling quite close to the line of the curve. Accumulation curves derived by C. H. Tutton, former assistant engineer, have the equations—

$$I = 0.65\,T^{[illegible]}$$
$$I = 0.50\,T^{[illegible]}$$

for "very heavy" and "heavy" rains, respectively.

The meteorological data applicable to Buffalo, as derived from 43 years' record, are:

Temperature: Mean, 46.9°, range +97° to −14°
Precipitation, mean, 36.89 in.
Snowfall, mean seasonal, 75.9 in.
Prevailing winds, from southwest

Labor Saving in Unloading Water Pipe

Some people are under the delusion that a labor-saving device is necessarily a machine of some sort, states Engineering Review of London. Nothing could be further from actual fact. A labor-saving device may be a machine, but often, and even in cases of great magnitude, there is very little, sometimes no handling machinery at all connected with it. A labor-saving device is primarily the application of experience and common-sense to the economizing of the power exercised by animate or inanimate motors, and the saving of time and money. In fact, the phrase is applicable to any expedient which promotes efficiency and economy in any industry or process. For instance, if a crane is employed to unload certain objects from the hold of a ship and if it takes 20 seconds for the crane to complete a cycle of action, its capacity may be doubled if the load is released after raising over the ship's side, i. e., doing half the journey, and is then allowed to proceed by gravity to its destination. The crane is thus only required to make a quarter of a turn instead of half a turn, and 10 seconds will suffice instead of 20. Thus, for instance, when the important system of pipes was laid to supply the British expeditionary forces in Palestine with water, the individual lengths of pipe, which were [illegible] and weighed a quarter of a ton each, were hoisted over the side of the ship in the Suez canal and then conveyed themselves by gravity, a distance of 150 ft. on inclined rail supports. The crane was thus employed for only half the time and therefore doubled in capacity, and if the pipes had been lowered to the ground level the force of gravity which conveyed them free of cost for 150 ft. would have been wasted. These are labor-saving devices.

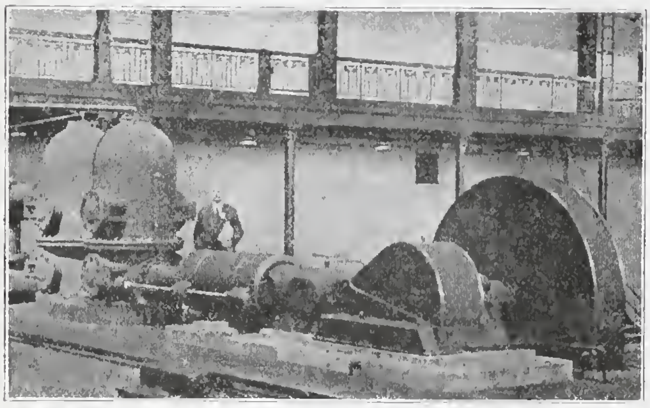
POWER AND PUMPING SECTION

This section of the Waterworks and Hydraulic Monthly issue of Engineering and Contracting is devoted to the selection of power and pumping equipment and the economic management of its operation.

The "Unaflow" Pumping Engine*

By D. E. DeCROW.
Chief Engineer, Worthington Pump & Machinery Co., Harrison, N. J.

The "Unaflow" steam engine derives its name from the fact that the steam travels over a path into and through the steam cylinder in one direction; it does not counter-flow or return over its own path. The "Unaflow" engine is not particularly new in principle but its successful development as a practical and economic commercial machine is quite recent and its adaptation to reciprocating pumping engine practice new.


"Unaflow" Pumping Engine.

Broadly speaking the general principle of the "Unaflow" reciprocating steam engine is that of utilizing the heat energy of the steam in the cylinder during the period of its admission, expansion and flow in one direction, the expanded steam being released or exhausted through ports or openings uncovered by the travel of the cylinder piston at that period of its stroke most remote from the point of admission; the comparatively cold expanded or exhausted steam does not counter-flow and pass through ports at or near the admission or hot end of the cylinder.

A typical "Unaflow" steam cylinder and a typical set of indicator cards from a condensing "Unaflow" engine are shown by the accompanying sketch.

In this sketch the piston is at one end of the stroke with the exhaust ports uncovered, the arrow indicating the path of the steam through the cylinder. It will be noted by examination of the indicator diagram that steam is admitted into the cylinder for only a very minor portion of the stroke and is then cut-off, the work performed during the remainder of the stroke being due to the expansion of the steam after the inlet valve closes. The exhaust opens when the piston, which is much longer than the ordinary engine steam piston, travels past and uncovers the exhaust ports midway between the two ends of the cylinder.

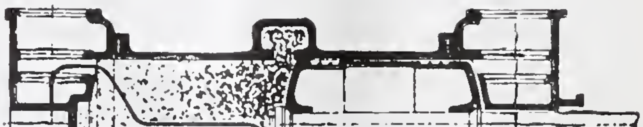
Beginning with the steam in the cylinder there is practically no change of temperature until the point of cut-off. After cut-off, expansion takes place with a consequent drop in temperature and at this time condensation begins, due to the changing of heat into work. As the cylinder head is jacketed with high steam no condensation takes place on the walls of the head, but the condensation is on the wall of the piston, which is comparatively cool and adjacent thereto, so that at the end of the stroke when the piston uncovers the exhaust ports the moisture of condensation is mostly at the exhaust end of the cylinder, and as the steam expanding away from the cylinder head rushes out through the exhaust port, it carries the moisture with it.

At this time there is a sudden drop of temperature in the cylinder due to the sudden drop of pressure, but as the inlet end of the cylinder is dry it does not lose its temperature, the flow of heat from a dry surface being slow and there is not sufficient time for any perceptible drop in temperature of these dry walls. The exhaust port is covered by the piston on the return stroke, trapping in the cylinder comparatively dry steam partially superheated; as the walls of the cylinders have retained their heat, the heat of compression is not absorbed either by moisture or by cold walls as in the case of a counter-flow engine and the steam remaining in the clearance is heated by compression to a temperature above the temperature of the initial steam; when the valve is opened to start the next stroke the live steam rushing in goes into a clearance space in which the steam entrapped is hotter than the entering steam, hence no initial condensation. Owing to the complete removal of all of the mixture on each stroke, the well-known heat losses caused by the presence of water in counter-flow engines are avoided.

Eliminating initial condensation permits an economical high ratio of expansion in one cylinder. For normal working conditions about 16 expansions have been found to give best results.

It is also evident with the use of exhaust ports in the cylinder instead of the usual exhaust valves, leakage losses at the exhaust valves and all of the added clearance space and surfaces which necessarily follow from the use of a special exhaust valve, are eliminated. It has been found practical to reduce the clearance space in condensing engines to three per cent of the swept volume of the piston.

Some of our manufacturers of "Unaflow" steam power engines have guaranteed as low as 10 lb. of steam per indicated horse-power per hour, and some of the tests of European built engines have shown well under 9 lb.


Typical "Unaflow" Steam Cylinder and Indicator Card.

Taking into consideration its simplicity, for with a single cylinder substantially the same economy is obtained as with the best types of compound or triple expansion steam engines, the "Unaflow" engine marks a distinct step in advance of the other types of reciprocating engines.

The advantageous features have attracted attention to its desirability as a motive power for reciprocating pumping engines.

To develop a pump that could be combined with and utilize the advantageous features of the "Unaflow" engine requires that due consideration be given to proper channels for passing the desired amount of water to and through the pump with the least practicable amount of deflection and disturbance of the flow. This can be attained by incorporating the "Unaflow" principle in so far as it will apply to a pump. The pump should be provided with passages ample and direct so there will be no reversal of flow, with plungers properly proportioned and formed to cause a minimum disturbance, with suitable suction and discharge air chambers properly located with pump valves that will deflect the direction of flow as little as possible, that will operate quickly and quietly at all pressures and economic speeds of the engine, and furthermore, that will be durable and lasting in operation.

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*Abstract of a paper read at the 39th Annual Convention of the American Water Works Association, June 9th to 13th.

The Practical Operation of Steam Boilers

Useful suggestions for securing efficiency in boiler room operation were given by Mr. W. E. Snyder, Mechanical Engineer, American Steel & Wire Co., in a paper presented before the Engineering Society of Western Pennsylvania. In connection with his paper Mr. Snyder submitted the following manual of instructions for boiler foremen:

When coal is fired in a boiler furnace, the heat goes one of four places:

1. Into the boiler.
2. Up the stack.
3. Into the ash-pit.
4. Into the air around the boiler setting.

Only the heat that goes into the boiler is used. The heat going the three other places is all wasted. The way to save coal is to reduce the waste. If you run the boilers in a way that will reduce the waste of heat up the stack, into the ash-pit and in the air, there is bound to be good boiler efficiency, which means saving in coal. The main work that has to be done to keep down the waste of heat is explained below.

You should read over and study carefully what is explained, so that when some one comes to talk with you about it later, you can explain your side of it. That is, if there is any kind of work mentioned which cannot be carried out right in your boiler house, you will have to study over the reason why it cannot be done and tell this to the man who comes to talk to you about these instructions. It is very necessary that you understand fully all about what causes the waste of heat, and also that you understand that what may seem like a little thing, which does not do much harm, is often the cause of a big loss because it goes on all the time, day and night. A good boiler house foreman looks after the little things, before they get to be big ones, and this often saves a whole lot of trouble and also saves coal.

Inspection.—After a boiler has been cleaned or repaired, you ought to inspect it carefully, outside and inside. It is a very good thing to have a union overall suit, with a hood on it, and draw-strings at the ends of the sleeves and legs. With this on you can go into any part of the setting without getting your clothes spoiled.

If you let the boiler go without inspecting, or entrust the inspection to some one else, you will never know what shape it is in. The way to keep the boiler in good shape is to make this inspection work part of your job, which it is, and do it yourself. The men will soon see that whatever work they do in the way of cleaning outside and inside is inspected before the boiler goes on the line again, and it will make them more careful.

When you inspect a boiler, keep two points in your mind all the time: First, is there anything wrong which might affect the safety of the drums or tubes or headers or connections, etc. Second, is there anything wrong which may cause waste of heat—for instance, dirt on the tubes; holes in the baffles; scale in the tubes; mud in the drums; any brickwork in need of repairing, etc.

It is most necessary to look through the tubes when inspecting. If the tubes run from one drum to another, put a man in one drum with a light. You get in the other drum and have him move the light so that you can see through the tubes. If you use an electric light in a boiler drum, be sure that the insulation on the electric wire is in good shape, or you might have a short circuit if a bare wire touched the steel of the boiler and some one would get badly burned. If the boiler is of a different kind and has tube caps on both ends of the tubes, be sure to take the caps off both ends of some tubes, scattered around in different places, and look through these tubes, with a light at the other end, as when looking through tubes to learn their condition. If you look from the lower end up, with a vertical boiler or a stirling type, and look from the back end forward in a straight tube boiler, then he will be sure to see any dirt or scale if there is any.

After you inspect the boiler outside and inside, you ought to make a note of its condition in your record book. The book should be big enough to last 2 or 3 years, and should be kept where it will be safe. When you make a note of the inspection, put down the date and the number of the boiler and anything which you saw that ought to be mentioned. If everything was all right, say so, but it is necessary that you write down something about the condition of the boiler and the setting, for your own information and also to use in case something should come up about the safety of the boiler. You cannot be too careful in making complete notes every time you examine a boiler.

Heat Loss up the Stack.—Most of the heat is wasted up the stack, and by keeping down this waste, the biggest saving of coal is made. A number of different things cause waste of heat up the stack.

If there are holes in the baffles, some of the gas will go straight through to the stack, without giving up to the boiler all the heat which it should give up. This makes the temperature of the gas in the stack higher than it ought to be and the way to prevent this is to keep the baffles tight. Sometimes when tubes are taken out, holes are knocked in the baffles and these ought to be fixed after the new tube is put in.

Another cause of heat waste up the stack is dust on the tubes. If the fire side of the tubes is not kept fairly free from dust, this dust will have the same effect as if the heating surface were covered with an asbestos sheet, which will keep part of the heat from passing into the boiler. The gas passes from the fire to the stack very quickly, and there is no time for the heat to soak through the layer of dust, as it takes much longer for the heat to pass through the dust than to pass through the steel of the boiler.

Blowing the dust off the tubes by hand, is something that you will have to look after to see that it is done right. Generally, once in 12 hours will be often enough, but it ought not to be put off any longer than this. Even if the flue blowers do their work as well as they can, there will be some corners that they cannot reach right. For this reason, the tubes ought to be blown off, or swept off, every time the boiler is taken out of service, and this is one of the reasons why you should inspect, as explained above. Do not let them blow water into the setting when first starting to blow, but blow the steam into the air until the blowing pipe gets hot. Wet steam in the cooler parts of the setting helps to bake the dust on the tubes, so that it will not blow off. If the boiler is wide and you can blow in only one side, it is better to use a longer lance for the part of the boiler farthest away, and a short one for the near side. Also you may find that a curved lance will help to reach some parts of the setting. Do not be afraid to use your head, and scheme out some things which will help the men to do their work right.

Another case of waste up the stack is scale or mud inside the boiler, on the heating surface. This has the same effect as dust on the outside of the boiler in keeping the heat from passing from the hot gas into the water. It is easy enough to keep the drums clean with water-tube boilers, and if you do not let it go too long, the shells of fire-tube boilers can be kept clean. The tubes have to be looked after the most, especially in the hottest part of the boiler. It is not hard to keep tubes clean if the work is done regularly. Use a turbine cleaner, and be sure that the size of the cleaner is right for the size of the tube. If the cleaner is too small, it will push through and leave a coating of hard scale. This is the reason why you should inspect the inside of the tubes after they have been cleaned. Don't allow the men to go through the motions of cleaning tubes without making sure that they cut out the stuff that is in the tubes. Always keep in mind that there is no excuse for any scale in the drums, and no excuse for even 1/16 in. of scale in the tubes, because with the good turbine cleaners that are now made, the scale can be kept out of the tubes if the cleaners are used often enough and the inside of the tubes inspected after the men are through cleaning.

One of the greatest causes of waste of heat up the stack is air leakage. The air which causes the greatest loss is that which gets into the setting through cracks in the wall and around the door-frames, between the boiler and the brick-work, between headers, and around the flue-blowing doors. All the air that gets in this way does no good at all, as it has no chance to burn coal, but it takes some of the heat away from the hot gas and carries it to the stack, and in this way keeps this part of the heat from passing into the boiler. All kinds of cracks in the walls between the headers and around door-frames, etc., ought to be plugged up in such a way that they will stay tight, and not have to be fixed over every few days. Asbestos rope is good for this, but it ought to be driven in tight. The worst leaks to stop are often around flue-blowing doors, because these doors have to be opened so many times. It is a good thing to have a bucket of asbestos plaster mixed up, and when a door with any leakage at all is closed, plaster up the cracks.

Do not forget that any air that gets into the boiler setting, except through the fire, is causing a waste. Holes in the fire, or thin places in back ends of stokers and chain-grates waste heat by letting in air. The fireman must be made to keep the grates covered evenly, to keep air from getting through which does not burn coal, but only carries away heat to the stack.

Still another source of loss of heat up the stack is due to putting too much water on coal. Dampening fine coal when it is used in some kinds of stokers and on chain-grates, is a good thing to do, but it is very easy to put on too much water. If you can see the water on the coal, or if you take a handful of fine coal and squeeze it and it balls up with the water running out, wetting your hand, there is too much water on; but if the handful of coal feels damp without making your hand wet, the chances are the water is about right. A little water is a good thing, but it is very easy to overdo it.

Heat Lost in the Ash-pit.—Do not fire the coal in big lumps, no matter what kind of grates you have. It is better in every way to break the big lumps, when the coal is hand-fired. If the coal is fired with stokers or chain-grates, it will be passed through a crusher before it comes to the stoker hoppers. The crusher ought to smash it up so that the big lumps will pass through a ring 1 or 1¼ in. in diameter. With chain-grates, if there are lumps even half as big as your fist, there will be coal wasted with the ashes, because these biggest lumps will not all burn out from the time they catch fire at the front end of the grates until ashes and all are dropped off at the back end into the ash-pit.

No matter what kind of grates you have, there will be some fine coal and coke dropped through the front part. With a chain-grate there is a pan which runs back part way, so that this can be scraped out and fired over again. You should do this same thing with a hand-fired grate or a sloping grate stoker. Have the firemen scrape out the good coal in the front of the ash-pit once in a while and throw it back into the furnace. Do not let the firemen start to clean fires with flat grates, with a lot of good coke lying in the front part of the ash-pits, because when they scrape out the clinkers, these will fall on this good coke and cover it so that it cannot be used again. Have the good coke scraped out and fired before starting to clean.

Once in a while you should look at the ashes as they are loaded in the ash-car or wheelbarrow to take them out, and if there seems to be much coke, find out what boilers it came from and watch the firemen that have charge of those boilers.

Keep on eye on the grate-bars. Sometimes bars burn off and leave holes, through which the fine coal falls into the ashes. Sometimes the openings in the bars or between the bars are too wide. In hand-fired grates these openings ought not to be more than ½ in. wide, and on stoker grates, it should be less than this. If the openings are greater than ½ in. or ⅝ in. at the outside, for clinkering coal, get the patterns changed. The waste of coal in the ashes can be kept down very low by paying attention to these things.

Heat Lost in the Air Around the Boiler Setting and Pipes.—Every metal part that has steam on one side and air on the other ought to be covered with a thick pipe covering. Do not be afraid to get the covering too thick on boiler heads, flanges, etc. It ought to be at least as thick as the covering on the pipes, or from 1½ to 2 in. The higher the pressure the hotter the steam, and with high-pressure steam inside and cold air on the outside, plenty of covering is needed to keep in the heat. All the heat that escapes from pipes with dry steam in them, causes some steam to condense and makes the steam wet. The water in the steam not only does no good, but it does harm, besides wasting the heat which was taken up by the boiler. When any covering is put on, no matter where, see that the work is done in a way that makes it look nice and adds to the appearance of the boiler or piping.

Firing.—In hand-firing do not let the fireman fire more than one door at a time, and do not let him put in more than three or four shovels of coal at once. A scoop shovel will hold from 15 to 20 lb. of coal, and over one-third of the coal is roasted out as a good gas a very short time after the coal is thrown on the fire. It takes a great deal of air to burn this gas that comes off the coal first and, if much coal is put on the furnace, not enough air will get through the bottom of the fire to burn the gas which is coming off. The result of this is that a good deal of this rich gas will pass to the stack without being burned at all, and this causes a great waste of coal. For this reason do not put on much coal at a time.

Do not have the fire too thick; 5 to 8 in. is thick enough. A thick fire wastes the good gas that is in the fresh coal, by keeping the air from getting through to burn the gas, and it also keeps the grate-bars too hot and burns them. With some kinds of coal a thick fire melts the ashes, so that a thin clinker runs over the top of the grate. Piling in coal and making a thick fire does not make the boiler steam fast. Only the coal that burns makes steam, and the coal will not burn fast if the air cannot get through the fire to burn it, or if clinker forms and stops up part of the air space.

Keep the fire even in thickness, except on chain-grates and mechanical stokers, where it ought to be allowed to thin out toward the ash end. The fireman should, by all means, watch the fires and keep them from getting too thick, and keep any thin spots leveled over. A thin spot lets a lot of air through that does not do any good, because it has no chance to mix with the burning coal or gas.

Do not let the fireman use the slice-bar very much, except when getting ready to clean fires. Let the fires alone, keep them from getting too thick; do not put in too much coal at one time, and the coal will burn and make a hot fire without digging and poking at it all the time. Once in a while if the ash-pit gets dark, it is all right to slide the bar around on the surface of the grate and make the fine ashes, which lie right on top of the grates, fall through the openings. This lets more air through and makes the fire burn better, but do not let the fireman force down the end of the bar and turn any part of the fire up-side-down and mix the clinker with the good coal. This will cause nothing but trouble.

Be careful in cleaning fires. Try to burn out the clinker as much as possible before it is dropped in the ash-pit or pulled out the door. In cleaning flat grates, throw the good fire over to one side and bar up slightly the clinker that is left, and then close the furnace and run for a little while until the spots in the clinker commence to look dark; then pull out all the clinker on that side and throw over the good fire on the empty grates. Put several shovels of coal on the good fire, and burn the clinker on the other side down in the same way. Do not let the fireman try to clean a very hot furnace with a thick fire. It should be burned down as just explained, then the fireman can work better in front of the furnace and not much coal will be wasted.

If the coal is very dirty and commences to "pile up" in the furnace and the fire gets too thick, even with all the draft on, it ought to be loosened up underneath with a bar, without pushing the bar up through the fire; then burned down as soon as possible and cleaned. There is nothing gained by shoveling coal on top of a thick fire after the ash-pit has gotten very dark, but a great deal can be lost in this way.

Dampers.—When you want the boiler to make less steam, partly close the damper. Never shut tbe ash-pit doors, as this is very bad in many ways. Do not let the men open the front doors of a fire-tube boiler and allow the cold air to blow in on the hot tubes. This is bad for the boiler and is no way to slow down its steaming. Always use the dampers, and fix them so that they can be used easily and set any place you want them. Do not have a damper that can be set only two places—wide open or shut.

After the fires are cleaned, do not allow a big pile of ashes to lie in front of the ash-pit doors and keep the air from geting into the ash-pit. Also, the fireman should not allow coal that has fallen in the ash-pit to lie there and burn. All such things keep the air from getting up through the grate bars where it will do some good.

Number of Boilers in Operation.—A very good way to waste heat, is to have more boilers on than what are needed for the load. In every boiler plant the boilers have a certain horse-power at which they make the most steam per pound of coal. With ordinary boilers this will run from 25 to 50 per cent over the rating, but you can get this very closely from the proper persons. From the number of boilers on, and the pointer and also the curve on the feed-water meter, you can see just what horse-power each boiler is averaging. From this you can judge whether there are too many boilers on. Do not have "loafing" boilers on the line, as this only wastes coal, and it wastes a great deal of coal too. It is much better to have one or two boilers banked, doing nothing, and the rest carrying the load running at the right capacity, than it is to have them all running and each one with a lower load than it ought to carry for best economy.

On Saturday nights and Sundays the load is altogether different, and a good deal of coal will be wasted at this time if too many boilers are kept on. After a man has been in charge of a boiler house for some time, he can easily learn from the meter about what the Saturday night and Sunday load will be. The boilers which carry this ought to run in the same way as they do through the week. It is altogether wrong to have more boilers on for this idle load than are really needed, and let them loaf along at any horse-power. A little study of the Saturday night and Sunday load will make it possible to run at good economy, summer or winter. The main thing to keep in mind is, that boilers running at one-half or two-thirds of their rating may waste more coal than when they are being forced too hard.

Other Heat Losses.—There are a number of other ways in which heat is wasted in a boiler house. All the steam which blows out of safety-valves is wasted. When the load is heavy and the boilers are working hard, and then the load suddenly drops off, the safety-valve will blow. All the steam lost out of the safety-valve means wasted coal. Some blowing is necesssary at times for safety, but there is no need for blowing a long time. This is where easy handling of the dampers comes in right. If the fireman will partly close the dampers and slow down the feed of the coal, the blowing will soon stop. Of course you must know the load conditions so that the fires do not cool down too much, and are then not right to take up the load when it comes on. You have to use common-sense in this, as well as many other things in operating boilers, as to just how much to slow down. You can often judge from the way the mill is rolling and the time of day the stops come. There is no use in safety-valves blowing hard for a half hour or an hour right along.

All leakage of hot water from blow-off valves is a waste of coal. Generally two blow-off valves are put on for safety reasons, but both of these can be used for economy reasons as well. Of course there is a waste that cannot be helped when boilers are blown down, but any leakage at the blow-off valves when they are closed means that they ought to be fixed as soon as it can possibly be done.

Most feed-water heaters have recording thermometers. You ought to keep an eye on the chart which shows the water temperature. This temperature ought to be 200° or over. Every 10° that the feed water is heated means a saving of about 1 per cent of the coal, so that if there is an average temperature of 150° in place of 200°, it means that 5 per cent of all the coal used is taken to do the heating which ought to be done in the feed-water heater. The feed-water heater also helps out the boilers, as when the boilers are getting hot water they will make more steam in an hour than when they are getting cold water. For all these reasons, do not be satisfied with a feed-water temperature that is under 200°. Of course you may go up as high as 208 or 210°, as the water boils at about 212°, and it cannot be heated above the boiling point. It is not a good thing to bail the water in the heater, because sometimes the pumps give trouble and there is nothing gained by it.

Do not forget about steam leaks, as all the steam that leaks out is wasted. Also, when steam leaks at one place for a good while, it will cut the metal and make the joint or stem harder to keep tight afterwards.

General.—In carrying out some things that have been explained above, you will need help from outside your boiler house. Do not be afraid to take up these things with your boss, and if taking them up one time does not do any good, take them up again—only be sure you are right. If you make an honest push to get things right, you will be backed up in what you are trying to do.

66 Oils and Oiling Pointers

The little notes that follow contain those that will be of service to everyone interested in power plant engineering. The pointers were selected by the editors of Power from the columns of that magazine.

(1) Special mixtures of oil are necessary in some cases, but for light machinery using only small quantities a mixture of 80 per cent light mineral and 20 per cent sperm is good and should not cost more than 50 ct. per gallon. It will not, however, stand heavy bearing pressure or form a film at slow speed. Its film thickness on metal is about 0.0002 in.

(2) Mineral shafting oil of dark color and medium weight without admixture with animal oil is found satisfactory.

(3) Good oil without adulteration, if used intelligently, is cheaper and more satisfactory than cheap oil, loaded to give bulk and to make it cost less per gallon.

(4) Heavy mineral oil with an addition of heavy animal or vegetable oil is best for high-speed shafts and electric machines having considerable weight to carry.

(5) Tallow oil, when derived from fresh tallow from properly fed animals, is a good lubricant, but lends itself readily to adulteration and may become rancid and acid. It forms the base of the best white soap, and if a large enough percentage of soap is added to the oil it becomes a grease.

(6) Cylinder oil containing fatty acid should be avoided as it is apt to injure the metal. The acid absorbed by the piston and valve-rod packing sometimes attacks the rods when the engine is out of service, to a serious extent.

(7) Pure mineral oils do not contain fatty acids, so that even a trace of acid is pretty conclusive evidence of a compounded oil.

(8) Viscosity tests, so called, do not necessarily prove anything of the lubricating quality of an oil, since rosin or other viscous oils may constitute a large proportion of the whole and yet have no lubricating value.

(9) Flashpoint determinations have no definite connection with lubricating power. None of the lubricating oils on the market have a dangerously low flashpoint. For gas-engine cylinder lubrication a reasonably high flashpoint is necessary.

(10) Testing for flashpoint may be done in a simple manner by heating a few ounces of oil over a gas flame and trying a lighted match over the surface of the oil until a wave of flame is seen to flash across its surface. The temperature of the oil when this occurs is called its flashpoint. Oils whose specific gravities are below 0.85 generally have flashpoints below 60° F., while those whose specific gravities exceed 0.85 have higher flashpoints.

(11) Lubrication is applied primarily to reduce friction.

(12) The effect of friction is to convert energy into heat.

(13) Heating is manifest soonest, with the same expenditure of energy, in small bodies because they are not capable of absorbing the heat generated, therefore feel hot to the touch, while the same energy expended on large masses will produce only a slight rise in their temperature.

(14) Specific heat of iron is 0.1138 B.t.u. per pound per degree F. rise in temperature or lb. × deg. × 0.1138 = B.t.u. absorbed, and each B.t.u. equals 778 ft.-lb.; therefore each pound of iron heated 1° F. has absorbed 0.1138 × 778 = [illegible] ft.-lb. of energy.

(15) Water jackets around bearings furnish means of carrying away the heat generated by friction in proportion to the pounds of water multiplied by the temperature increase in ° F., the specific heat of water being unity.

(16) Air circulation conveys heat away from bearings in proportion to its amount, specific heat and temperature increase.

(17) Oil flowing through bearings conveys away a portion of the heat equal to its weight, specific heat and temperature increase.

(18) An occasional squirt of oil on a bearing is the worst form of lubricant—a feast-and-famine process, wasteful and insufficient, therefore inefficient.

(19) Drop-feed oiling without means of collecting the oil after going once through is wasteful, although otherwise satisfactory as long as the flow is not interrupted.

(20) Self-oiling bearings have the merit of using the same oil continuously without waste other than by slight vaporization and creeping, but proximity to a heated bearing

the oil at a higher temperature than it is at its best for lubricating.

(21) Some buy the lowest-priced oil because it is the cheapest (in price); others buy oil best suited to their use even if higher-priced, because it is the cheapest in the end.

(22) Vegetable oils will wash out of fabrics, but mineral oils will not.

(23) Rosin oil is cheap and its specific gravity high, therefore it is sometimes used to adulterate lubricating oil. When it has been considerably refined, it can be added in large quantities without much chance of detection except by a chemist; but since it has no lubricating qualities, the action of the mixture will be unsatisfactory.

(24) Oil containing paraffin will emulsify, in warm water, more readily than if without, and on being allowed to stand in a glass vessel, will show a whitish film between the oil and water when cooled.

(25) Cottonseed and corn oils are sometimes used in lubricating oils, but have merit only as cooling elements, for thread cutting and the like. Their high specific gravity (92 to 93 per cent) makes the mineral oil to which they are added deceptive when too much dependence is placed on viscosity.

(26) Carrying power of a bearing is the term used to express the greatest permissible bearing pressure.

(27) Frictional resistance of a bearing is the resisting torque, or so-called moment of friction, or it may be defined as the quotient of the resisting torque by the mean radius of the journal.

(28) A filter will soon recover its cost in oil reclaimed. Using oil repeatedly without throughly cleansing it is likely to cause trouble.

(29) Oil does not wear out, but does need treatment to cleanse and purify it.

(30) The lightest oil that can be safely run usually produces the lowest coefficient of friction and should be given preference, especially where power cost is high.

(31) Heavy (viscous) oil may fail to distribute evenly in close-fitting bearings and allow some parts to become injured while other parts are flooded.

(32) High fire test oil is necessary to lubricate bearings operating at high temperature; other oil may actually increase the bearing temperature.

(35) The lightest oil used for lubrication has a specific gravity of about 0.865 and the heaviest about 0.930. The commercial range is from 0.885 to 0.907.

(34) Throwing water on burning oil spreads the flame and makes matters worse. Sand, flour or sawdust in sufficient quantities to smother the flame by excluding the air will extinguish an oil fire.

(35) Effect of viscosity may be made clear by remembering that when a lubricant adheres, to a certain extent, to two surfaces having a different rate of motion, a shearing stress is set up at every point within the lubricant in splitting or separating the two parts from each other and the work so done is manifested in heat generated.

(36) The law of fluid motion is that the force required to shear a layer of fluid, of a given area of the element in plane of shear, and thickness, normal to the plane of shear, is directly proportional to the relative velocity (surface speed of journal) of the two surfaces and to the area, and inversely to the thickness, of the fluid.

(37) Greases are used for extra heavy work, although some of the so-called hard oils are but little more viscous when heated to running temperature than heavy oil. Generally speaking, it may be made from almost any kind of mineral oil mixed with soap until it is of the desired solidity. Various other substances have been incorporated in such grease, such as graphite, sulphur and the like for special work, giving good success.

(98) A reliable grease may be made from good cylinder oil and tallow or tallow soap mixed to suit.

(39) Selecting oils may be best done by trial, like the proverbial pudding, and when a satisfactory mixture is found, have it analyzed and require the same ingredients in the same proportions in future purchases.

(40) A little good oil in the right place is better than a whole lot elsewhere.

(41) Lubrication by forced circulation is the best method known, where the oil is delivered into the bearings under pressure in a copious stream, collected and returned after being filtered and cooled. Pressure and large passages insure an ample supply, and the comparatively cool oil conveys heat from the bearing in proportion to its weight, specific heat and temperature rise.

(42) Oil for air-compressor cylinders should have a flashpoint of 550 to 600° F., according to the air pressure and rapidity of compression; for steam cylinders, operated with superheated steam, upward of 600°, according to the amount of the superheat. Saturated steam will not disintegrate oil of 550° flashpoint. For internal-combustion engine cylinders, oil of as low flashpoint as will do the work should be used (about 450°), as the heavier oils are apt to leave a sooty residue.

(43) The specific gravity, viscosity and flashpoint of various oils are approximately as follows:

Kind.	Sp. gr.	Viscosity at 100° F.	Flash-point.
Light mineral	0 860 to 0.875	27 to 35	340 to 360
Medium mineral	0.875 to 0 890	44 to 47	380 to 400
Heavy mineral	0.890 to 0.910	47 to 86	400 to 440
Cylinder mineral	0.900 to 0.905	350 to 900	500 to 550
Sperm	0.875 to 0.885	35	
Lard	0.910 to 0.920	60	
Tallow	0 910 to 0.915	65	475 to 500
Rape	0.910 to 0.915	55	
Olive	0.915 to 0 920	60	
Castor	0 960 to 0.970	270	
Cotton and corn	0.920 to 0.930	55	600
Rosin	0.960 to 1.000	50	

(44) Tests are best conducted on the individual bearing on which the oil is required, no two conditions are exactly alike. In practice the lubricant to select is that which is the best for the average of a given class of bearings operating under nearly the same conditions, to minimize the grades or kinds to be kept in stock.

(45) Lubricating chain drives is best done with thin oil first, to penetrate into the joints, followed by heavier oil, according to the working temperature and speed, applied with a brush while the chain is running slowly. Greases are not suitable for thorough lubrication of chain drives.

(46) Durability of oil depends more on its use, or treatment, than on any inherent quality it may be supposed to possess. A rapid circulation of oil through the bearing so that it will not become overheated and vaporized is the most satisfactory and economical treatment for the oil.

(47) Relative value of lubricants depends on first cost, wastage of the lubricant, difference in the power cost chargeable to them and the cost of application or attention, all of which are widely variable quantities.

(48) Necessary qualities in oils vary to some extent, but first of all always, there must be sufficient body, biscosity, for the pressure in order to keep the surfaces from harmful contact, that is to do the work. The other qualities may rank differently in importance under differing conditions. They are, freedom of corrosive acids, fluidity, minimum coefficient of friction, high flashpoint (for safety) and freedom from oxidation or "gumming."

(49) Animal and vegetable oils all have two characteristics in common—they oxidize or gum on exposure to the air and they will cause spontaneous combustion when spread thinly over inflammable material. Linseed oil is an example of a gumming oil—desirable for paint but not for lubricating. All seed oils have this tendency in some degree.

(50) Wick or capillary oilers, where the upper end of the wick is in contact with the shaft or moving part and the lower end is immersed in the oil, feed upward by capillary attraction—similar to an oil lamp. Another form conveys the oil by a wick by the same principle from a reservoir to the elevated end of a tube into which the wick is thrust thence by gravity to the bearing in drops similar to the drop-feed oiler.

(51) Friction of lubricated surfaces is determined by the nature of the lubricant rather than by that of the solids or bearing metals themselves.

(53) Projected area of a bearing is equal to the diameter of the shaft multiplied by the length of the bearing.

(54) Pressure per bearing inch is the total pressure divided by the projected area of the bearing.

(55) Required bearing area is the total pressure divided by the allowable pressure per square inch, giving the required projected area in square inches.

(56) Required bearing length is the total pressure divided by the desired pressure per square inch, and this again divided by the diameter of the shaft; or the projected area divided by the shaft diameter.

(57) Allowable pressure per square inch ranges from 10 to 30 lb. for high-speed shafts in babbitted bearings, to 100

lb. for large slow-speed shafts. Engine crankpins often sustain 1,000 to 3,000 lb. per square inch.

(58) Speed of minimum friction is the rate of motion at which, if varied from, either faster or slower, the friction of a bearing increases. With perfect lubrication it is believed to be between 100 and 150 ft. per minute.

(59) Morin's "Laws of Friction"—(1) The friction between two bodies is directly proportioned to the pressure; that is, the coefficient is constant for all pressures. (2) The coefficient and amount of friction are independent of the areas in contact, pressure being the same. (3) The coefficient of friction is independent of velocity, although static friction (friction of rest) is greater than the friction of motion.

(60) Pressure on bearings—Slow-speed alternate: Crank pins, 1,000 to 3,000; crosshead, 1,000 to 1,200; main bearings, 800 to 900;; guides, etc., 25 to 60; lineshaft, 10 to 30.

(61) Friction of lubricated surfaces approximates to that of "solid friction" as the bearing becomes dry and to that of "fluid friction" as it is flooded with oil.

(62) Antifriction metals, so called, are useful for lining bearings chiefly because of the ease with which they can be formed (poured) and their abiilty to permit crushing and abrasion without a great increase in friction, not because they have a lower coefficient of friction; hence antifriction is a misnomer.

(63) Coefficient of friction means the proportion of the pounds pull (or push) to the pounds (weight) being moved over a given horizontal surface; that is, wood on wood without lubricant may have a coefficient of 0.5, or require ½-lb. pull to move one pound along slowly. Or, coffiecient of friction is the ratio of the force required to slide a body along a horizontal plane surface to the weight of the body.

(64) Friction in an engine, as determined by three sets of tests, is distributed approximately as follows:

Main bearings	47.1	35.4	35.0
Piston and rod	32.9	25.0	21.0
Crankpin	6.8	5.1	
Crosshead pin	5.4	4.1	13.0
Vaive and rod	2.5	26.4	
Eccentric strap	5.3	4.0	22.0
Link and eccentric	0.0	0.0	9.0
	100	100	100

(65) Cylinder oil and boiled linseed oil equal parts are said to have given good results on a hot crankpin in one instance.

(66) Acid in oil will cause corrosion when in contact with moisture. The presence of sulphuric acid may be determined by a solution of barium chloride in distilled water, a few drops of which put into the oil after it has been thinned with an equal amount of gasoline or benzine will cause a whitish precipitate if acid is present. In the absence of moisture the acid is not so active and may escape notice.

The total friction of a given engine remains practically constant under all loads and should not exceed 5 to 8 per cent of the full-load capacity of the engine. It increases with steam pressure from 30 to 70 lb. after which only slight increase is noted. Increased speed generally increases the total friction, but not always.

How to Burn Fine Anthracite.—In a paper read before the New England Waterworks Association Mr. Alfred O. Doane, Division Engineer of the Metropolitan Waterworks, Boston, calls attention to the fact that in some localities it is possible to obtain the fine sizes of anthracite, mostly washery products, at prices which will show important savings over bituminous coal in the cost of generating steam. He states that unless there is a strong draft, no large proportion of the fine anthracite can be burned economically, and it may be necessary to install forced draft and otherwise make changes in the equipment, the first cost and carrying charges on which must of course be considered. It is, however, possible to obtain forced draft fans directly connected to steam turbines which are not expensive, are easily installed, and will furnish sufficient draft to successfully burn all grades of fine coal and at the same time add greatly to the flexibility of the plant when dealing with variable loads. When forced draft is used with a vertical boiler, there is considerable danger of burning the lower tube ends, especially if holes in the fuel bed cause a blow pipe effect. A grate with small air spaces will reduce this danger.

Method of Banking Fires

An excellent method for banking fires is described by Mr. Clifford F. Danner in a letter in Power, from which we quote as follows:

The manner of banking fires depends largely on the kind of coal, the time the fires are banked and the quickness with which the banks must be knocked down and the fires gotten under way. Some coals ignite easily and require only the hot furnace to ignite them, but with others a certain amount of fire must be left upon which to throw the green coal. Sometimes the bank has to be covered with ashes to keep the coal from burning out and running up the pressure, which is undesirable. The plant under consideration consists of 72-in. x 16-ft. return-tubular boilers with 6 x 6-ft. hand-fired grates, both shaking and stationary. The fires are banked an average of 12 hours each day of the year.

Contrary to usual practice I have the fires banked on the front of the grates. The live coal is pushed well back to the bridge-wall and all ash raked out. The live coal is then pulled to the front and green coal is piled upon the live coals, completely covering them in some cases and only partly so at other times, depending on the coal. The bank can be placed well up on the dead-plate or more on the grate, depending on the kind of coal. This gives a certain amount of control of the bank, so that the pressure will not run up and cause the safety valve to blow; at the same time the bank can be allowed to burn well through.

When it is time to get the fires going, it is only necessary to spread the bank and put on the draft, and in a few minutes the fire is good and hot, ready to make steam enough to pick up quite a load. And this ability to get under way quickly is important where boilers are banked in readiness to supply steam to fire pumps in case of a fire alarm or when considerable load must be picked up quickly. Some bank the fires just as they are when shutting the boilers down, by covering the fire with green coal and then cleaning when starting up, but I do not like that method.

The quantity of coal required to bank a fire under each boiler as I have described runs from 90 to 125 lb. As a rule 90 lb. is sufficient. Plants requiring as much as one-third of the total coal consumption for banking must operate but a small part of the time or else the fires must be kept burning slightly in order to supply leaks and thus hold up the pressure.

To obtain the best results from banked fires and keep stand-by losses down, it is necessary that steam leaks through valves and traps, also hot-water leaks, be kept as low as possible.

Where the steam lines are kept hot, nothing should be lost from the boilers but the condensation, and sometimes it is advisable to cut the boilers out entirely. It is surprising how much water a boiler will lose on account of a few steam leaks even when the fires are banked.

Removal of Frazil by Electric Current.—In a paper "Design of Hydro-electric Plants for Combating Ice Troubles," presented last winter before the Engineering Institute of Canada, Mr. R. M. Wilson stated that frazil suspended from the surface ice could be removed by use of electric current. The small quantity of heat generated by the passage of electric current between electrodes, inserted through the surface ice, disintegrates the suspended spongy ice mass very quickly. 2,750 kw. will free an area of approximately [illegible] sq. ft. of this spongy ice, having an average depth of 7 ft., in about 30 minutes. The voltage required with a spacing between electrodes of 32 ft. is 6,000 volts.

Use of Explosives in Breaking Up Ice Jams.—Experiments at the Cedar, Que., hydro-electric plant of the Cedar Rapids Mfg. & Power Co., in breaking up [illegible], showed that the best results were obtained with an explosive made from ammonium nitrate having a strength equivalent to 30 per cent nitro-glycerine dynamite, made up in sticks 2 in. in diameter and 8 in. long. This explosive, giving a large gas volume, was slow in action and gave very satisfactory results. It has the advantage also of not freezing unless the temperature is [illegible] or more below zero, and if left in the water an hour or longer dissolves and is not dangerous. Tests were made with ordinary 40 per cent nitro-glycerine dynamite in sticks of 1½ in. in diameter and 8 in. long, made up in charges of 7 to 8 sticks, but these were all too fast and would only pot-hole the ice.

MANAGEMENT AND OFFICE SYSTEM

This section is published twice a month: (1) In the Waterworks and Hydraulic Monthly issue, and (2) in the Railway and Excavation Monthly issue. It covers what may be broadly termed "management engineering" as applied in the civil engineering and construction fields.

Suggestions for Improving Specifications

By HARRY G. PAYROW

Sanitary Engineer, C. E. Department Lehigh University.

In issuing specifications it does seem that a little more attention should be given to certain phases of the matter so that they will appear attractive in the sense of being easily read, of convenient size, well indexed and with serviceable covers and binding.

Generally the inspectors and field men desire to carry a copy of the specifications in their pocket but if of the usual typewritten variety they are easily mutilated, and if printed they are generally so bulky that one cannot find a suitable pocket for them. Hence the field men are discouraged in this respect either on account of the size or fragility of the specifications or both. Thus the work may suffer in view of the fact that some point in the specifications will not be referred to at all as either the inspector has not time to return to the office or it is forgotten in the whirl of the day's work.

An examination was recently made of many printed and bound specifications. These varied in size considerably, many being very large (7¾ in. x 10¼ in.) while the majority were 6 in. x 9¼ in. and in a few cases as small as 3¾. in. x 6½ in. Typewritten specifications were generally 8½ in. x 13 in.

After a consideration of the above sizes and the needs of the field men, a size is suggested that is deemed convenient for the pocket, with a length and breadth of good proportions and well adapted for its purpose. The bound copy should be 4½ in. x 7 in., which easily slips into the pocket and its size would not render it too bulky. As a further means of decreasing its fragility the corners of both the covers and pages should be rounded, preventing to a large extent the tearing or crumpling of the leaves.

The covers should be of a heavy manila paper or light cardboard similar to the material of which heavy paper shipping tags are made. This material makes a very tough, flexible cover not easily torn. The binding can be of black linen and all bound securely by three wire binders.

The type to be used is an important matter and affects both the size or bulk of the book, and its attractiveness. Again upon examination of several specifications it was found that a great variety of type was used, many of them being so small as to render rapid reading difficult. A size suitable should be similar to that used in the Engineering and Contracting, which would in most cases keep the book from being too bulky and yet easily read. The arrangement of the printing also needs attention. Liberal margins should be allowed so that notes may be written in from time to time, either as defects in the present specifications to be corrected in future cases or perhaps a section which requires special attention may be easily so marked.

Each section of the specifications should stand out distinctly that the eye may easily catch the title or sub-title, which should be of a somewhat larger type, as:

Clearance for Forms.

The excavation, whether in earth or rock, shall be of sufficient size to allow, etc.

As a further means of clearly defining each item, and section thereof, a decimal method of numbering each may be used to good advantage. As an illustration the following will clearly show the method.

Item 1-A
Excavation—General Earth
Above Elevation 63.

Section 1.1. All excavation under this item shall include, etc.

Unauthorized Excavation.

Section 1.2. If the bottom of any excavation, etc.

Maintenance of Excavation.

Section 1.3. The contractor shall maintain, etc.

Payment.

Section 1.9. For the excavation and disposal of materials, etc.

Item 1-B.
Excavation—Earth Below Elevation 63.

Section 1.10. All excavations under this item, etc.

Every section under 1 has a consecutive number in the form of a decimal, while the whole number represents the Item. As can be seen, Item 1 may be divided into any number of parts, each receiving an alphabetical letter. Thus Section 1.16 is contained in Item 1 and is a sixteenth section of that item.

Item 2-A.
Surface Dressing Work to Be Done.

Section 2.1. Surfaces of refills and embankments, etc.

Payment.

Section 2.4. The price stipulated, etc.

This method positively defines a section especially in correspondence where many times a misunderstanding arises as to just the section mentioned or the intended section is misconstrued.

The additional cost of printing and binding specifications compared with typewritten sets may in many cases be unwarranted but will depend on the magnitude of the work or where standardized specifications may be used it is generally found expedient to have printed and bound specifications.

As a comparison of cost, a set of specifications which also included information for bidders, tender and contract for a pumping station, intake, equipment and pipe connections contained 90 pages, approximately the size suggested in this article. Covers of heavy tag page and (3 wire) cloth binding. The present cost of which would be approximately as follows: Fifty copies, $63; 100 copies, $72; 250 copies, $94.

The same set of specifications if typewritten would cost for fifty approximately $48; 100 copies, $95, and 250 copies, $138. Thus many times if a large number of specifications are to be produced the printed form after all is the most reasonable while for a limited number the extra expense is not so very excessive.

To further facilitate the rapid use of specifications an index worthy the name should accompany it.

This may require some time to properly index or cross-index all titles as for instance testing of sand might well be indexed under that name and also under sand tests and mechanical analysis. There is nothing so disheartening as to turn to an index and find only listed there a few titles and those of a general character, as "excavation" or "testing," followed by perhaps many page numbers, which means that one must go through them all to find just the reference needed.

Another method used is to make up the index consisting of familiar phrases, just lines of paragraphs or essential words in paragraphs. As an illustration the following have been selected:

	Page.
Catch basins are to be repaired by	21
Material delivered on the side of streets	25
Pavements, lines and grades	4
Rubbish removal and surplus material	24
Settlement, defects or damages, etc	22

It is fitting that, as specifications play such an important part in construction work, they should receive more attention along the lines of this article than they have apparently heretofore. The caliber of the work and those connected therewith may even be "sized up" by the completeness of the details, of which this subject matter is only one of the many occurring to receive careful attention.

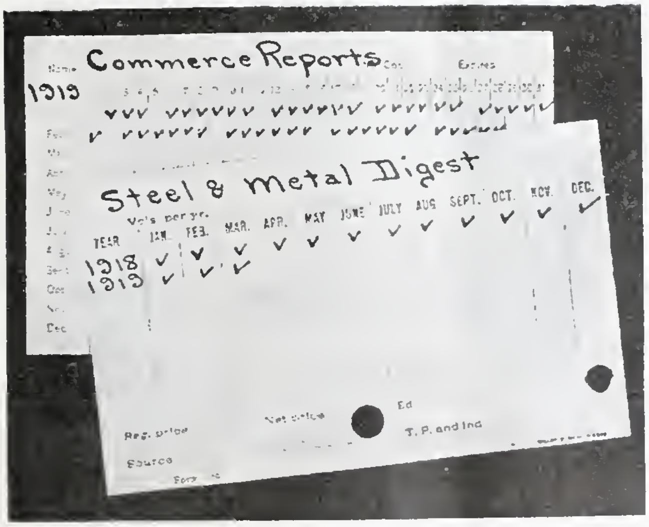
The Business and Professional Library*

By LOUISE B. KRAUSE.
Librarian, H. M. Byllesby & Co., Chicago.

The Value of Periodicals.—Periodicals are the most fruitful source of information for any business, and there is periodical literature of value being issued constantly on every conceivable subject. Every industry and profession has its journals and in them will be found the latest and best information.

The value of periodicals in a business organization was very ably stated some time ago by the secretary of an electrical association, and as this testimony is not from a librarian but from a practical business man, it seems worth while to quote as follows:

> The technical or trade journal of today is the livest and most "up-to-now" assistant a business man has. It is carefully edited, well printed, fully illustrated and thoroughly indexed both as to literary matter and advertisements. It is the "always ready reference" of the minute, and the official, head of a department, or even workman, who does not use it to its fullest capacity, is neglecting one of his best friends. I have been surprised to find how many of the larger companies are actually stingy when it comes to paying out money for subscriptions to their trade and technical journals. They talk about one, two or three dollars per year as if it were that many hundreds; they look at the expenditure as if it were an expense instead of an investment, which, properly handled, will bring good returns.
>
> In no other way can any business man, no matter how high or low his position, keep so fully abreast of the times in his business as by early and careful perusal of his trade and technical periodical, from its front to its back cover, and from no other source can he obtain the "immediately useful" so well as he can from a well filled and indexed present volume of those same publications.



Check Cards on Periodicals Which Enable the Librarian to Know if All Copies to Date Have Been Received. On the Back Is Noted the Date of Renewal of the Subscription.

"Printer's Ink" has also stated the case as follows:

> The manufacturer, desirous of keeping his finger on the pulse at Washington, who will spend $10, or $15, or $20 a year for business papers and other periodicals that specialize with respect to business news from the national capital, can be pretty well assured that he has every tip that could come to him via the intelligence office, that asks a fee of $50 or $100 per annum. Indeed, it has before it was sent out in the mimeographed "letters" and "bultial" and "not for publication."

The Contents of Periodicals.—Not only do periodicals contain lengthy articles on special subjects, but every item in them from cover to cover is of value; for example, in engineering periodicals the business library is greatly aided by the current news notes on books, pamphlets, meetings and people; information on state and federal legislation; prices of materials and second-hand material for sale or wanted to purchase, new construction notes, new devices and best makes of standard supplies.

The brief notes found in current periodicals, announcing the publication of trade pamphlets, reports of state boards, special committees, private corporations and bulletins published by universities, [illegible] and papers presented at [illegible] meetings of associations are [illegible] valuable guides in collecting pamphlets, which although in many cases may be had for the asking, represent a collection of valuable data which can not be replaced by the expenditure of any amount of money and yet [illegible] a polite letter of request.

Aids in Selection of Periodicals.—The business [illegible], or the business librarian will first of all desire to select the periodicals that best cover the needs of his organization. If he wishes to ascertain the titles of periodicals on special subjects in order to obtain sample copies for examination, or if he has the title and wishes to find the frequency of issue, the place of publication and subscription price, there are several books that give such information and which should be found in the public library of his city. It is advisable also for him to see a list of all periodicals which are on file at the public library with a view to examining those which may be suited to his immediate needs. The following books will give information about periodicals on special subjects:

Ayer & Sons' American Newspaper Annual Directory, published by N. W. Ayer, Philadelphia. $5.00.
1600 Business Books, published by H. W. Wilson Co., New York, 1917. Price $1.50.
Severance Guide to the Current Periodicals and Serials of the United States and Canada. A new edition will be published shortly by George Wahr, Ann Arbor, Mich., price [illegible]. This new edition will contain a list of House Organs published in the United States. A recent list of House Organs may be found in Printer's Ink, August 29, 1918, and subsequent issues.
A list of periodicals published by the United States Government can be obtained free of charge from Superintendent of Documents, Washington, D. C.

The Checking of Periodicals.—The care of periodicals is one of the important pieces of work which consumes a large portion of the business librarian's time. All periodicals received by the business library are stamped, as soon as the mail is opened, with the word "Library" and the name of the firm,, and checked on monthly or weekly card record size 3 by 5 in., specially ruled for the purpose and obtainable from library supply firms. This card record enables the librarian to know if all copies to date have been received and on the back of the card also provides a record of expirations and renewals of subscriptions.

The Indexing of Periodicals.—After the periodicals are checked, the librarian should go through them rapidly keeping well in mind all the topics of particular interest to the organization, and also special requests from individuals for the latest information on subjects, which they have designated as being of present value to them. It is a good plan also to ask heads of departments who read periodicals regularly every week, to call the attention of the librarian to any special articles which they think valuable and to which they might wish to refer again. This strengthens the librarian's reading and makes doubly sure that no information of importance is overlooked.

All articles or items of importance are assigned a subject heading (which will be discussed in the article on cataloging), and a card is made for the subject card index to periodical material.

Some one may ask at this point why it is necessary for the librarian to do subject indexing to periodical articles when there are good printed indexes to them, such as Readers' Guide to Periodical Literature, Industrial Arts Index and the Agricultural Index, published by H. W. Wilson Co., New York City, and in addition The Engineering Index, recently acquired by the American Society of Mechanical Engineers and published monthly in the Journal of that society. There are several reasons why subject indexing must be done by the librarian: first because these printed indexes do not index many of the periodicals which are of importance to the business library, and second, because in the periodicals which are covered by these indexes, there are many items of importance to business firms which are too short to be entered in the general printed indexes. The time element is also an important factor in the business library, as the subject card index is made at once and immediately ready for reference, while the printed indexes are of [illegible] to date. For example, an engineering [illegible] keeping up to date on all increases in [illegible] throughout the country, due to the increased [illegible] tion, on account of higher prices of materials, [illegible] nals reported such items each week, [illegible] than a dozen lines. In such a case the librarian's [illegible] reading and [illegible] indexing was [illegible] vice not to be expected of the printed index.

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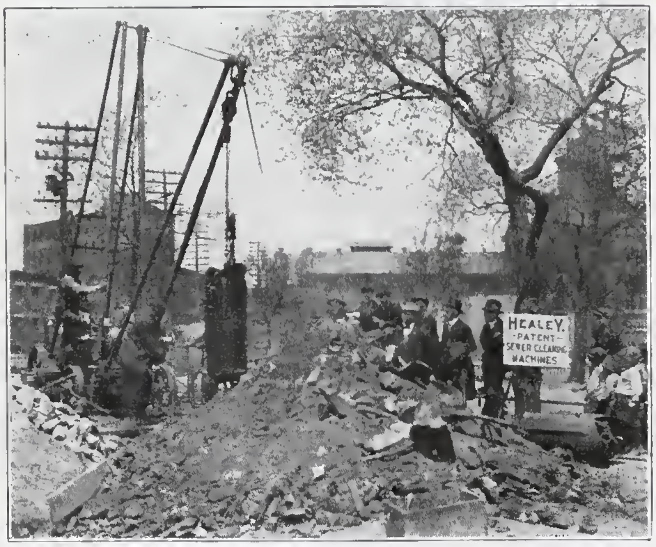
*From the Journal of Electricity.

A word should be said, however, at this point in regard to the value of printed indexes, for example, the "Industrial Arts Index." Periodicals are sealed books without indexes, and printed indexes are invaluable working tools, first, because no business librarian will attempt the impossible task of making a subject card for every article of value in current periodicals, and second, because a live business organization in these days of sudden changes in economic conditions cannot possibly foresee every subject in which it may be interested. When these unexpected subjects arise for which the business librarian has not made provision, the printed indexes come to the rescue and serve the need most admirably. The indexes to separate volumes of individual periodicals, which the publishers issue at the completion of each volume, and in many cases do not send unless requested to do so, are not of great value because, with few exceptions, the subject indexing is poor. Many of them invert the title of the article in order to enter it under the most striking word which it contains, without consideration of its real subject content, and without further consideration of the three, four or more subjects on which the article is very likely to contain valuable information.

New Sewer Cleaning Machine



Healey Sewer Cleaning Machine.

A sewer cleaning machine that eliminates the necessity of workmen entering the sewer has been invented by P. J. Healey, 39 Cortland st., New York City. The cleaning device consists broadly of a hollow body mounted on wheels and closed at its rear end, and provided at its open end with a shovel. The body, when filled, is raised to the surface by means of a power hoist and derrick, brought to the cart and emptied. The machine is operated from the surface of the ground and is so constructed that it will work as well in a sewer full of water as in one that is dry.

Unit Cost Estimates for Small Hydro Electric Plants.—As a consequence of the high cost of fuel attention is being devoted to the investigation of many small water power possibilities. In this connection the following data, from the Electrical World, based on an estimate of the construction cost of a 180-kw. installation in Massachusetts, are interesting. The total estimated cost of the development was $50,000, or about $277 per kilowatt (March, 1919, prices). The unit costs in the estimate included:

Earth excavation, per cubic yard	$ 1.50
Ledge excavation, per cubic yard	4.00
Two 90-kw. generators, per kilowatt	40.00
Installation of generators, per kilowatt	8.33
Two 42-in. turbines, 21.4-ft. head, per kilowatt of plant generating capacity	38.80
Installation of turbines per kilowatt plant generating capacity	8.33
Gates and racks, per kilowatt	2.78
Concrete wheel casing and draft tube installation, per kilowatt	5.55
Power plant building, per square foot (brick)	6.00
Concrete canal and forebay, per kilowatt	28.80
Concrete penstock (length 740 ft., inside diameter 5 ft. 6 in.), per kilowatt	55.50
Engineering and incidentals	24.50

Personals

E. I. Heinrich has resigned as city manager of Boulder, Colo., and has accepted the position of professor of criminology at the University of California.

Charles E. Henderson, formerly District Engineer, United States Housing Corporation, has been appointed principal assistant engineer of that corporation.

John H. Lance has opened an office in the Second National Bank Bldg., Wilkes-Barre, Pa., where he will engage in a consulting civil engineering practice.

J. M. Lewis, formerly city engineer of Sioux City, Ia., has opened an office at 203 Trimble Block, Sioux City, and will engage in engineering and contracting.

E. C. Miller, for the last two years testing engineer for the Kilbourne & Clarke Manufacturing Co., has resumed his former partnership with his father, G. M. Miller, in the hydraulic and general engineering field. The offices are in Burke Bldg., Seattle, Wash.

W. F. Monfort, Consulting Chemist, has terminated his service as acting professor of sanitary chemistry at the University of Illinois and has resumed his practice in the examination and purification of potable and industrial water supplies. His offices are at 506 N. Vandeventer Ave., St. Louis, Mo.

W. Thomas Wooley, formerly City Engineer of Auburn, Hoosick Falls, Schenectady, Syracuse, and again of Schenectady, a graduate of R. P. I., Class of 1900, has recently been appointed engineer in charge of construction of the new state prisons at Sing Sing and Wingdale. The appointment was made by State Superintendent of Prisons Rattigan. Mr. Wooley will receive $6,000.

George A. Johnson, whose partnership with Major W. L. Benham was announced in this column a short time ago, was promoted on July 3 to the rank of Colonel. Colonel Johnson entered the service in the spring of 1918 as Major, and was promoted to Lieutenant Colonel on November 7, 1918. He is now Second in Command of the Operation and Repair Branch of the Construction Division of the Army, which has charge of the operation and maintenance of roads, railroads, buildings, water supply, sewerage, electrical and all other utilities in the various establishments under the jurisdiction of the War Department.

Industrial Notes

The Gauld Supply Co., Inc., has taken over the business of the Gauld Co., Portland, Ore. The directors of the new company are: Wm. P. F. Ayer, president; Thos. Nickerson, vice-president; G. A. Ricker, treasurer; Theo. W. Little and Carl T. Keller, all of whom are prominently connected with the Walworth Manufacturing Co.

The Blaw-Knox Co., Pittsburgh, Pa., has opened offices in the Little Bldg., corner Boylston and Tremont Sts., Boston, Mass., and in the Owen Bldg., Detroit, Mich. A. W. Ransome, formerly of the New York office, assumes the duties of New England manager. H. J. Desson has been transferred from the Pittsburgh office to assume the duties of manager of the Michigan district.

E. A. Hitchcock has become connected with the Bailey Meter Co. of Cleveland, O., as vice-president. He will supervise the training of technical graduates for the company's service and sales departments. During the past 6 years he has been connected with the E. W. Clark and Company Management Corporation as advisory, consulting and power sales engineer. Previous to that time he was professor experimental engineering at Ohio State University.

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and [illegible]
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials

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San Francisco's Municipal Railway Is No Gold Mine

Under this same title there appeared an editorial in our issue of Feb. 19, which M. M. O'Shaughnessy, City Engineer of San Francisco, criticised in our issue of May 21. Mr. O'Shaughnessy said: "This editorial is so unfair and misleading, due to the tone and the suppression of part of the report, that I can not let it pass without comment." He then undertook to prove that the municipal railway system has been "profitable," thus:

"For the construction of these municipal railways San Francisco has bonded itself for $5,500,000. From the operating revenues of the system, in addition to paying all operating expenses and maintenance charges, the city has paid the interest on the bonds and has redeemed the bonds as they have matured to the extent of the $404,000; has constructed extensions to the system at a cost of $800,000, and has created a reserve fund for depreciation and insurance of $1,000,000."

Unquestionably Mr. O'Shaughnessy is honest in his belief that such figures refute our contention that "the municipal railway is no gold mine." And we are equally sincere in stating that the data fail to substantiate his belief. We "suppressed" no data in our editorial for the purpose of misleading our readers. Elsewhere in this issue appears an article giving the data by years for 5½ years so [illegible] that any one may judge for himself as to the fairness of our original statement that this municipal railway is "no gold mine.'

Mr. O'Shaughnessy is not an expert in railway [illegible]. The editor is. Mr. O'Shaughnessy is an advocate of municipal ownership. The editor is not. While neither personal experiences nor beliefs will solve such problems as this, they can serve to direct the attention of the reader to the relative importance of the statistical evidence.

Mr. O'Shaughnessy and the editor differ [illegible] in the definition of "true net earnings." The former contends that a charge for taxes, equivalent to what the city [illegible] would have paid had they been privately owned, is a "fictitious charge." The editor contends that it is no more fictitious than is a charge for interest on the entire investment, [illegible] the object is to show the relative profitableness of a municipal railway as compared with a privately owned railway.

Mr. O'Shaughnessy also differs from the editor as regards the depreciation charge. He says:

"It should be noted that the ordinary privately owned and operated railway [illegible] does not provide a [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]."

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

In the article elsewhere in this issue the editor points out that the depreciation annuity plus the annual expenditures for currrent repairs has averaged only 7 per cent of the cost of the San Francisco municipal railway. This is no more than is necessary over a long term of years. Mr. O'Shaughnessy makes the very common mistake of regarding the annual maintenance expenditures on a new plant—such as the San Francisco municipal railway—as being comparable with an average over a long term of years.

Mr. O'Shaughnessy points to the fact that privately owned railways do not set aside depreciation annuities. Apparently he fails to see that the older a railway becomes the smaller need be the depreciation annuity in excess of current maintenance expenditures, for with greater age comes greater immediate expenditure for upkeep. But aside from this fact the failure of privately owned railways to set aside a depreciation reserve is not a sound argument against such reserves. A depreciation reserve is not unlike a fire insurance fund. It may never be needed in its entirety, but it may be needed to the limit. In the case of street railways, invention and the growth of the business have repeatedly rendered obsolete the major part of the plant. And the absence of depreciation funds has often compelled railway companies to carry in their capital accounts large amounts of abandoned plant. Street railways, taken as a whole, have not yielded 6 per cent true net earnings on the invested capital. But the American public has seen a few large fortunes made in street railway securities by speculative financiers, and has leaped to the conclusion that street railways are highly profitable. Disillusionment will soon occur if many more cities follow the example of San Francisco and Seattle and try to make money on a nickle fare where companies have failed.

The Unfairness of Politicians Toward Street Railway Companies.

Robert M. Sweitzer, the democratic candidate for Mayor of Chicago at the last election, appealed for the support of the voters on the ground that he would oppose raising the street car fares. He said:

"I know of no reason why the city should guarantee the revenues of a public utility corporation any more than it should guarantee the revenues of any private business house. I know there are many business men in the city who would be delighted to have the city guarantee them against loss, but I don't believe that many of them have the nerve to ask it. I am ready to fight the proposition for an increase to the last ditch, but I want to make an effective fight. I want to make one which will count and not merely obtain a certain amount of space in the newspapers. I believe that I can do it and I ask the voters to put me in a position to do so."

Unfortunately Mr. Sweitzer's brand of politics is still on the market in other cities where street railway fares should be raised. In Denver, for example, the city authorities have put the 6 ct. fare back to 5 ct., on the ground that because the war has ended the city need no longer "guarantee" adequate revenue to the company. It is a favorite argument of politicians that a city might as well guarantee the revenue of a private business house as of a public utility. The fallacy of the argument lies in the fact that private business houses are free to raise their prices whereas public utility companies are not. Public utility companies would gladly give up their claims to a "guaranteed revenue" were they free to establish their own rates or prices. But since the public has chosen to regulate public utility rates, it follows that the public should guarantee a fair return on the value of the property used in public service.

Mr. Sweitzer said in his appeal for votes:

"I intend to be absolutely fair to every one as Mayor. I am not going to take a stand because I think it is popular if I think that it is also unjust.

"At the present time the local transportation companies are making a demand for increased fares, based solely upon their report for the last year. That report shows a loss in earnings which they insist can only be met by an increase in fares.

"I do not believe that the position of the traction companies is correct. Even taking their own report as evidence and admitting a loss, what is more natural than that there should be one? Other companies which are making annual reports show losses in earnings."

It is a peculiar brand of "fairness" that denies to a public utility company an increased fare because "other companies show losses in earnings."

Not satisfied with sophistries, Mr. Sweitzer mistated the street railway company's argument for higher fares when he said that it is "based solely upon their (financial) report for the last year." That report was used merely as evidence of the greatly increased cost of operation and the consequent reduction in net earnings. The main argument for increased rates is based on the permanent increase in operating expenses resulting from the great rise in wages and prices.

The street railways of Chicago must have a greater revenue if they are to earn a fair return on the investment. Mayor Thompson recently spoke of the "watered stock" of the traction lines, yet he should know that the properties were all appraised several years ago, and that there is no "water" in the appraised value upon which the company asks for a fair return.

The unfairness or ignorance—it matters little which—of the Chicago politicians who have opposed rate increases will surely lead to municipal ownership unless steps are taken to offset it. Yet the very daily papers that shout loudest against municipal ownership are silent when it comes to editorial discussion of the inadequacy of the 5-ct. street car fare.

The Two Theories of Freight Rates

American freight rate schedules are complex and a continuous source of litigation. For 12 years one city—Spokane—has kept up with its fight to secure as low rates from the east as are enjoyed by Seattle and other Puget Sound ports. To the merchants of Spokane it will always seem unfair that they pay much more per ton-mile than is paid by merchants of Seattle. They will never be convinced that "water competition" entitles Seattle to lower rail rates.

In like manner there are scores of thousands of business men who will not be persuaded that the ton-mile rate on high priced goods should be higher than that on low priced goods. What, they ask, has the value of the goods to do with the cost of handling them by rail? They never will be satisfied with the reply that "freight rates are based on what the traffic will bear," for among business men there is an abiding belief in the economic theory that prices should be based on costs.

Competition among railways originally led to basing freight rates on "what the traffic would bear." Will this theory of rate making, which is based on "value to the consumer" ever give way to the theory of basing rates on the cost to the railways? There is prospect that it may. If the railways are returned to their owners under a plan that will perpetuate their present co-operative administration, competition between railways will practically cease. Of course competition between business men and communities will remain, and for a time that may serve to maintain freight rates based on "what the traffic will bear." But in its efforts to satisfy different competing communities as to the fairness of freight rates, the Interstate Commerce Commission is likely to find it necessary, more and more, to adopt the theory of basing freight rates on cost.

Viewing the rate question as an economic problem in which the greatest economy to the country as a whole is sought, it seems that a correct solution can be arrived at only by basing freight rates on costs. We are aware of the difficulties that are involved in applying the cost theory of rate making. There is, for example, the celebrated illustration of the two railways between two cities, one railway having a much higher cost of transportation than the other. Shall freight rates between the two cities be based on the cost of transportation over the more costly road or over the less costly road? This question is "a poser" under competitive conditions, but it is more easily answered under non-competitive conditions.

It is not our present purpose to discuss in detail the solution of such problems. We wish merely to direct attention to the fact that if Congress should decide to perpetuate the non-competitive system of railway administration that the war brought into existence, the old theory of freight rates based on costs will be revived, and may eventually drive out the present practice of basing rates "on what the traffic will bear."

E. & C. Index Furnished Only on Request

Previous to last year it had been our custom to send the index of our articles to all subscribers. In common with many other publishers we now have adopted the practice of sending the index to only such subscribers as request it. Therefore, if you want the index for the 6 months ending June 30 you should notify us at once. Those who requested the index for the previous volume have been listed and need not notify us again.

Accident Prevention at Grade Crossings

To the Editor: While approaching a railroad crossing the other day in company with a civil engineer, I made the remark that it would be a splendid thing for both automobilists and the railroads, if the railroads would construct at each grade crossing a road running parallel with the tracks, so that if an automobilist was threatened with collision he could turn his car to the right or left, and thus avoid hitting the locomotive or moving train. Such a road should be banked so that the automobilist could make a short turn without difficulty, even though the car was traveling as fast as 30 miles an hour.

This civil engineer thought so well of the idea that he urged me to write you.

Experience has shown me that it is impossible for the automobilist to see whether a train is approaching from either direction at 99 grade crossings out of 100, until his car is either upon the tracks, or so near them as to make it practically impossible for him to stop, should a train be approaching.

A banked road running parallel with the railroad tracks on both sides would enable an automobilist to escape accident in the majority of cases and need not be more than 150 ft. in length.

For example: A chauffeur turned to the left at Leonia crossing of the Northern Railroad of New Jersey the other day, but having no roadway to run upon, he was compelled to take to the rails and the car was overturned, killing the chauffeur, but saving the lives of the passengers, none of whom were seriously injured. Had there been such a roadway as suggested above he could undoubtedly have saved both himself and his machine.

No doubt the Maintenance of Way Departments of the railroads will declare that in a great many cases it would be impossible for the railroads to build such a roadway, owing to the lack of room; and for other reasons, but where there is a will there is a way.

This leads me to point out another fact, which is common to the experience of automobilists, and that is, that the rattling of the auto makes it almost impossible for one to hear the crossing-bell, should a bell be ringing; for which reason the railroad should place a signal at least 150 ft. distant from the railroad tracks, which would warn the automobilist that a train is approaching.

I have already pointed out that in 99 cases out of 100 it is impossible for a driver of a car to see whether or not a train is approaching, so that a signal of this kind would be a very great advantage.

Crossing signals consisting of red lights have been installed by the electric railway between Paterson and Suffern, N. Y., over all the grade crossings. When lighted, even in the day time, the red lights are visible at a considerable distance, so that there is ample time for a driver to stop his car, and a signal of this kind should be installed by the railroads, so that the driver may depend upon his eyes for the warning signal, rather than upon his ears.

It is needless to argue that most automobilists are reckless, because the average driver has no desire to risk his own life, or the lives of his family and friends, and it is only a very few who take wilful chances.

ALBERT L. WYMAN,
Secretary, Employers Association of Paterson.

Has the Municipal Railway of San Francisco Shown Adequate Profit?

By HALBERT P. GILLETTE
Editor of Engineering and Contracting

The San Francisco Municipal Railway has been operating 6½ years under sufficiently favorable conditions to give some idea of the best that can be expected of municipal ownership of street railways in America. This railway system serves well populated districts, and its passenger revenue per car mile has averaged 32 ct. for 5½ years. The population is proud of its municipal lines, favoring them at the expense of other lines. The management has been quite free from political pulling and hauling. The entire plant is a "new broom," that is sweeping as vigorously as possible in competition with the privately owned "brooms." Power is secured at a very low rate.

All in all, this municipal railway has had an unusual opportunity to show an excellent profit on the investment. Yet its true net earnings over the first 5½ years of its history have averaged only 5 per cent annually on the average investment in the plant. By true net earnings I mean the balance remaining after deducting current operating expenses, a depreciation annuity, an accident insurance annuity, and a sum equal to the taxes that the system would have paid had it been privately owned. The city officials deny the right to call this balance "true net earnings." They use the expression "fictitious charges" in referring to the charge for "lost taxes"; but the taxpayers, who have had to go down into their own pockets to make good the taxes that this city railway system would have paid had it been privately owned, would scarcely call their payments "fictitious."

The city charter provides that the municipal railway must annually set aside 14 per cent of its gross revenue to provide a depreciation fund with which to renew the plant as it wears out or becomes inadequate or obsolete. The charter provides that 4 per cent of the gross revenue must annually be set aside as a reserve with which to pay for accidents. And it provides also that the "lost taxes" must be calculated and shown in the financial reports each year, in order that the citizens of San Francisco may not be deceived as to the real economy of municipal venture. But so eager are the city authorities to prove the venture to be an economic success that they call these lost taxes "fictitious charges." During the first 5½ years these "fictitious charges" have totaled $719,212, or $130,[illegible] a year, or 2.93 per cent annually on the average investment in the plant. Evidently if the loss of these taxes is purely fictitious loss, as the city officials wish the public to believe, another story would be told. But the fact is that these lost taxes are a real loss that should not be called "fictitious" even by the most ardent socialist.

From a recent financial statement issued by the City Engineer of San Francisco I have compiled Table I. Excepting the last two lines, every figure in this table is official. I have omitted the bond interest, since that is not germane in estimating the annual percentage of true net earnings. In any problem involving a demonstration of the economic results of operating a revenue producing plant the customary method is to show the annual true net earnings as a percentage of the investment in the plant. It serves only to becloud the issue if interest on bonds is introduced, for some plants are not bonded at all while other plants are bonded to the full extent of their cost, or even more in [illegible] cases. This municipal railway was bonded for $5,077,[illegible], June [illegible], 1918, as against a plant cost of $6,2[illegible].

Table I shows the income by years. The following table gives the total income for the entire 5½ year period:

Operating revenue	[illegible]
Operating expenses	[illegible]
Net revenue	[illegible]
Lost taxes	[illegible]
True net income	[illegible]
Average annual true net income ([illegible] years)	[illegible]
Average investment in plant	[illegible]
Average true net income as a percentage of average investment	[illegible]

This average true net income of 5.0[illegible] per cent would barely pay bond interest were the plant bonded to its full cost. Yet the San Francisco municipal railway [illegible]

TABLE 1—INCOME OF THE SAN FRANCISCO MUNICIPAL RAILWAY FOR 5½ YEARS.

Year ending	Dec. 31, 1913	June 30 1914	June 30, 1915	June 30, 1916	June 30, 1917	June 30, 1918
Miles single track	16.18	22.62	43.04	46.63	46.63	*63.95
Cost at end of year	$1,657,251	$2,654,529	$5,042,331	$5,396,707	$5,838,791	$6,265,801
Revenue per car-mile	34.19 ct.	36.87 ct.	32.96 ct.	30.99 ct.	27.65 ct.	34.08 ct.
Operating revenue	$ 444,748	†$ 521,720	$1,638,664	$1,982,805	$1,477,911	$2,375,930
Operating expense	291,431	366,597	1,226,115	1,525,875	1,240,281	1,832,554
Net revenue	153,316	155,123	412,549	456,930	237,630	543,376
Lost taxes	35 454	44,138	138,254	166,714	125,576	209,076
True net income	117,862	†110,985	274,295	290,216	112,064	334,300
True net income as per cent of average cost	7.16	†5.15	7.12	5.56	2.00	5.52

Note: In estimating the "average cost" of plant for each year, the costs at the first of the year and at the end of the year are added together and divided by two.

*Includes 6.53 miles of joint track and operation rights. †For six months.

alded far and near as a striking proof of the profitableness of municipal ownership! Of course, it can be made show a seeming profitableness, for by ignoring the "lost taxes" (2.93 per cent), the average net revenue becomes 7.98 per cent on the average investment during the 5½ years.

It is claimd by the city officials that the $1,180,000 set aside for depreciation in 5½ years is excessive. It is equivalent to about 4.8 per cent annually on the cost of the plant. The maintenance expenditures (other than depreciation charges) of this plant have annually averaged slightly less than 2.2 per cent of the average investment in the plant. Hence if we add this 2.2 to the 4.8 we get 7 per cent for combined maintenance and depreciation. As a result of my appraisal work and operating cost studies for the Washington Railroad Commission and for street railway companies, I have come to the conclusion that fully 7 per cent on the entire cost of an electric street railway system should be allowed annually to cover current maintenance and depreciation charges over a term of 20 years or more, even where the depreciated fund earns 5 per cent compound interest. This conclusion is based on actual data relating to plants ranging from 18 to 30 years in age. Included in the necessary 7 per cent are all repair and renewals of pavements, ties, rails, rolling stock, etc., as well as provision for a depreciation fund equal to the accrued depreciation of the plant.

It is true that street railway companies have rarely built up a depreciation fund equal to the accrued depreciation, but it is equally true that the economic result of operation is deceptive unless an adequate depreciation annuity is considered. It may be wise to distribute the equivalent of the depreciation annuity in the form of dividends, as most companies have done, although I doubt the wisdom of such a procedure. A wiser practice would be to invest the depreciation fund in plant additions and improvements, as has been done in the San Francisco Municipal Railway. But to contend that a depreciation annuity need not be earned is an economic mistake.

Probably the most prosperous of all large utility companies is the American Telegraph & Telephone Co. (the Bell system), whose practice has long been to provide a depreciation reserve equal to the accrued depreciation, so that the depreciated value of the plant plus the depreciation reserve equals the first cost of the plant. The depreciation reserve is usually invested in plant extensions. Thus the stockholder is protected and the public is served at a fair price. If you choose, you may regard the depreciation reserve as a surplus. There appears to be no other way in which a public utility, whether publicly or privately owned, is likely to be allowed to earn a substantial "surplus," except in the form of a depreciation reserve.

The street railways of America have, as a whole, never earned enough to pay fully 6 per cent on the cost of the plant and provide also an adequate surplus or depreciation reserve. We are now witnessing their financial distress consequent upon the false economic policy of living from hand to mouth. In the early days, the development cost (or deficit in fair return on the investment) led to the policy of contending that no depreciation reserve need be provided. In later days the lengthening haul without increase in fare, perpetuated this false policy. Now we see a fruition of disaster. Public service commissions have gladly accepted the policy that no depreciation reserve is needed for railways. They have never permitted rates that would provide a substantial surplus. So when an economic storm has come, we find all railways—steam and electric—in a dangerous condition.

I have digressed somewhat, yet the digression seems warranted, for the city officials of San Francisco seem inclined to regard the annual depreciation charge of 14 per cent on gross earnings (equivalent to 4.8 per cent on cost of plant) as excessive. My contention is that past experience justifies that charge. If so, the San Francisco Municipal Railway system has barely earned 5 per cent annually on the investment during the first 5½ years of its existence. Hence it has not been the gold mine that its proponents have pictured it. When they point to the large extensions built out of earnings after paying bond interest, they deceive themselves and the public if they regard that as evidence of profit. Those extensions are in part built with the depreciation fund and in part with the "charge for taxes." These "taxes," be it remembered, have annually averaged nearly 3 per cent of the plant cost, and in 5½ years have aggregated $719,000—a very tidy sum, yet no more than would have been paid into the city and state treasuries had a company operated this municipal railway.

It seems to me that if the citizens of San Francisco really wish to know how profitable their street railway is, they should demand an annual report by an independent consulting engineer experienced in appraisal and rate matters. Their city engineer is an honorable man but not an expert in such matters. The officials in charge of the railway would be more than human if they did not put the most favorable interpretation on all the data.

Answering the question that heads this article, my reply is that the 5 per cent true net earnings of the San Francisco Municipal Railways is a poor return on the investment considering the risks involved. That there are serious risks is shown by the fact that for the year 1917 the true net earnings were only 2 per cent. It is further shown by the recent decision (Apr. 16) of the Board of Public Works to draw upon the million dollar depreciation fund to meet the 12 per cent increase in wages of the platform men. The wage rate is now $4.50 for 8 hours and there is no doubt that it will go higher, for common laborers on the Pacific Coast are earning $4 to $5 a day.

If with a greater density of traffic than the private lines in San Francisco enjoy, the municipal railway barely earns 5 per cent on the cost of the plant, even during the "new broom" period, there is slight prospect that municipal ownership of all lines in the city will be adequately profitable.

Quarry Accidents in the United States

Accidents at quarries in the United States during 1917, according to returns made to the U. S. Bureau of Mines, showed a decrease in the number of fatalities as well as in the fatality rate per 1,000 men. The fatality rate in 1917 was 83 per 1,000 workers (300 day) as compared with 2.20 in 1916. Non-fatal injuries, however, increased from 175.62 per 1,000 workers (300 day) in 1916 to 185.14 in 1917. Of the fatalities 1.27 was due to accidents in and about the quarry while .56 was owing to various causes outside the quarries. The fatalities due to the use of explosives in the quarry amounted to 23.07 per cent of the class total; 48 per cent of the fatalities resulted from premature shots, and 19 per cent from transportation. As regards the minor injuries, the larger percentage was from returning too soon. The fatality rate in the quarries producing building stone was 1.04 per 1,000, as compared with 2.08 per 1,000 at those producing crushed stone. The difference in fatality rates in the outside works is similar, the figures being 0.52 for building stone and 1.39 for crushed stone. The nonfatal injuries in the building-stone quarries were 190.50 per 1,000 (300-day workers), whereas in the crushed-stone quarries they were 193.35 per 1,000 (300-day workers). The nonfatal injuries in the outside works handling building stone were 153.96 per 1,000, as compared with 297.25 per 1,000 in the crushed-stone industry.

Excavation Methods on the Miami Conservancy Project

By G. L. TEEPLE,

Assistant Engineer, Miami Conservancy District.

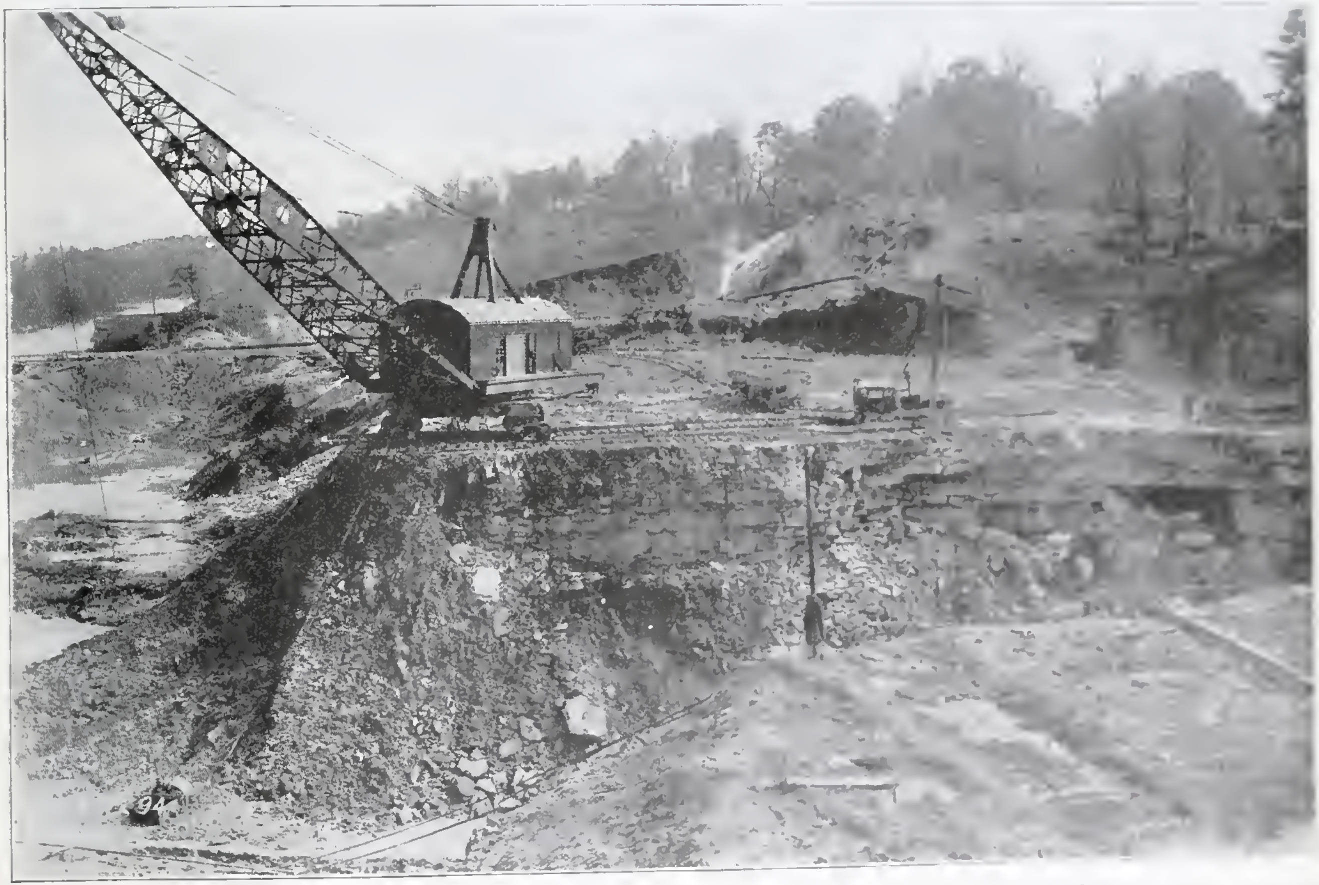
The flood prevention project in the Miami Valley, Ohio, involves the construction of five large earth dams, behind which flood waters will back up in retarding basins. The dams will be pierced at the base by concrete outlet conduits founded on solid rock, which will carry the ordinary river flow and through which the retarding basins will empty themselves after flood. The project involves also the raising and strengthening of levees through the cities of the valley below the dams and the deepening and widening of the river channels to carry enlarged flow.

The project thus calls for a very great amount of earth excavation. The dams will take from 865,000 to 3,500,000 cu. yd. of earth each, totaling for the five close to 8,500,000 cu. yd. The river excavation, much of it through the manufacturing cities of Dayton and Hamilton, will amount to about 7,500,000 cu. yd. A very considerable yardage will also have to be moved in the rebuilding of the Baltimore & Ohio, Erie, Big Four, and Ohio Electric Railways, which had to be relocated higher up on the valley slopes to take them out of the limits of the retarding basins where they would be subject to flood. The excavation required for this railway work totals 2,150,000 cu. yd. The grand total of earth thus required to be moved in connection with the flood prevention project amounts in round numbers to 18,000,000 cu. yd.

For the railway work standard methods by steam shovels and dump cars have been adopted. About 700,000 cu. yd. of the railroad excavation is in one cut, of which 600,000 cu. yd. is rock. A considerable quantity of this rock is loose. The rest must be blasted.

The dams are to be built by hydraulic fill, as giving the most impervious structure with the additional advantage of least cost. At three of the dams the best material for the fill is found on the rather flat, broad, valley floor, much of it below ground water level where excavation by steam shovel would be out of the question. The [illegible] might be [illegible] dredge, cableway or dragline excavator. At [illegible] dams (Taylorsville) also for a considerable [illegible] borrow pit, the same conditions prevail. The [illegible] Taylorsville is necessary excavation on the [illegible] connection with the outlet conduit system. At [illegible] (Lockington) the entire borrow pit is situated on the [illegible] slope. For these borrow pits on the slopes it [illegible] whole best, the fill being hydraulic fill, to make the excavation by means of hydraulic jets or monitors served by high pressure centrifugal pumps. By the monitors [illegible] places a total of about 1,500,000 cu. yd. is being excavated.

For the 7,500,000 cu. yd. of river work steam shovels [illegible] also for the most part inapplicable since a very large portion of the excavation must be taken out under water. Here, as at the borrow pits for the dams situated in the valley bottoms, either dredge, cableways or dragline excavator might be used. As between the three methods the dragline [illegible] the job in hand decided advantages and [illegible] adopted.



Rock Excavation for Outlet Conduits of Taylorville Dam. View Taken May 13 1919

View is upstream. Excavation for hydraulic fill by monitor in middle distance. Rock down to [illegible] by the machine without blasting. Below that level blasted. Deep excavation at right is for hydraulic [illegible] works. Miami River at left. Embankment at extreme left is earth cofferdam to protect excavation [illegible] electric Class M Lidgerwood.

There are some 21 of these machines at work [illegible] Conservancy District with buckets varying from [illegible] yd. capacity, and with booms ranging from [illegible] length. Most of these machines are driven by electric [illegible] tors, 60 cycle, high tension alternating [illegible] Dayton Power & Light Co. [illegible] almost all the work of the Conservancy District. [illegible] tric machines give excellent [illegible] have decided advantages over steam machines. [illegible] however, the latter has [illegible] machines are in use.

At the dams the [illegible] the draglines is [illegible] 40-ton locomotives and dumped [illegible] is washed by hydraulic jets into a [illegible] dredge pumps convey it [illegible] the hydraulic fill on the dam. [illegible] Taylorsville, as has been [illegible] terial will be washed directly [illegible] row pit to the [illegible]

Cut for Double Track Railway Through Huffman Hill. View Taken on Feb. 18, 1919.

Total depth of cut, 119.6 ft. Quantity in cut, 700,000 cu. yd., of which 600,000 cu. yd. is rock. Work done by steam shovels of about 70-ton size.

draglines are important factors on certain parts of the conservancy work, as in excavating for the hydraulic pump pool at the foot of the outlet works at the dam. At the Huffman dam, for instance, a dragline has excavated to a depth of 60 ft. below the dragline track. At the Taylorsville dam a dragline is expected to excavate to a depth of about 75 ft. below the dragline track.

In the river improvement work at Dayton and at Hamilton much material is deposited by the dragline directly from the point of excavation to the levee or spoil bank. Another considerable fraction is deposited in place by two handlings. In the latter method the dragline when digging in midchannel, deposits the excavated material in a long windrow toward the shore. By traveling the length of the windrow a second time between it and the bank, the machine can place the material in its final position in the levee. By two handlings the large class 175 Bucyrus draglines in use on the work in Dayton can place material 500 ft. or more from the point of excavation. Many thousands of yards have thus been handled twice. For work in midchannel in deeper water the dragline is mounted upon a scow equipped with spuds. A part, however, in both places—40 per cent in Dayton and 80 per cent in Hamilton—must be transported from the point of excavation to the point of deposition by auxiliary means; in Dayton by scow and steam tug, and in Hamilton by dump car train.

The reason for the difference is that at Dayton the river improvement is essentially a job of deepening the channel while at Hamilton it is essentially a job of widening. At Dayton, a manufacturing city of 160,000 people, the river before work began already occupied practically all the space between the two levees through the main part of the town.

Excavation for Outlet Conduit at Englewood Dam. View Taken September, 1918.

Excavation was done with the Class 24 Bucyrus dragline shown in view. The rock is Cincinnati shale. The upper layers were dug by dipper; the lower layers were blasted and excavated.

Finishing Levee Just Below Hamilton. View Taken Feb. 7, 1919.

Slope at left is original river bank. Slope at right levee, which is being top dressed for seeding. Levee built from Miami River excavation by Class 24 Bucyrus dragline.

The width thus occupied is sufficient for the enlarged channel. There thus remained no space where a construction track could be laid alongside the river, which would be free from obstruction of buildings, trees, etc., and at the same time not liable to flood in case of a rapid rise of the mouth of the river such as not infrequently occurs during the spring season. At Hamilton, on the other hand, the river flows in a constricted width through the main part of the city, requiring in fact the wrecking of buildings along the banks in several places in order to give sufficient width for the proposed improvement. It is thus easy to lay a construction track on this comparatively high safe shelf, along which material excavated from the channel can be transported with little fear from high water during the flood season. During the dry season the tracks at Hamilton, as a matter of easier convenience in loading, will be carried on the dry portions of the river bed at a much lower level.

The scows at Dayton used for transporting the material are 40 by 120 ft., 6 ft. deep, and will carry 300 to 350 cu. yd. of material. They were built on the job. They are loaded by a Class 175 Bucyrus Dragline mounted upon a 40 by 80 ft. scow. They are unloaded into the levee by a similar dragline carried on the usual trucks and mats on shore. This dragline unloads the material directly from the scow into the levee or spoil bank. The scows are pushed up and down the river by a small stern wheel steam tug of the Mississippi River type, 20 by 70 ft., of shallow draft, which was built in Dayton for the purpose.

In order to provide sufficient water in the river through Dayton during the dry season, a small timber dam was built across the river, about midway in its course through the city, raising the water at that point about 4 ft. A second timber dam at a lower point will be built for a similar purpose to complete the second stage in the river improvement. For this last stage, comprising somewhat more than half the total excavation, the scows will not be used. The material will be placed in the levees by the excavating dragline, either directly or by double handling as heretofore described.

The entire work is being carried out under the direction of Mr. Arthur E. Morgan, chief engineer, to whom the original inception and formulation of the plans for flood prevention are due. He is aided by Mr. Charles H. Paul, assistant chief engineer, and by Mr. C. H. Locher, construction manager, who exercises general superintendence over all the work of construction.

Rapid Erection of Trolley Poles

Mr. F. B. Walker, Superintendent of Electrical Construction for the Chicago, Milwaukee & St. Paul Ry., Seattle, Wash., has given in the Electric Railway Journal some record figures on a rate of setting up trolley poles along the track of the above railway.

A gin pole built up on a push car and operated along the track is the principal feature of the time-saving method employed. Using this device, poles up to 50 ft. long have been set with a crew of four linemen and about three helpers, including a teamster, the team being used for hoisting the trolley pole and moving the push car from setting to setting. Additional men, of course, were used to line poles and backfill, following the setting crew.

With this rig the rate of progress has been as high as 108 settings per day and has averaged about 70 poles per 8-hour day. Before the portable gin pole was built the average made by the hand method was about 50 poles per day, and this meant hard work on the part of the crew. The gin pole has a total length of about 18 ft. and is slung, about 6 ft. from its lower end, on a horizontal pin supported on a heavy frame built up from an ordinary push car. The gin pole itself is strengthened with longitudinal steel cables passing over central struts so as to form trusses.

The trolley poles are laid with the pickup point immediately over the hole, thus making it possible to place them with a direct lift. The use of this rig avoids the danger of knocking dirt into the hole in course of erection and thereby decreasng the effective depth.

The hoisting equipment consists of a block and tackle slung from the upper end of the gin pole from which the hauling line runs through a snatch block attached to the rail below. The team does the pulling. The gin pole can be easily reversed in its supports for use in setting the poles on the opposite side of the track.

Experience of France in State Operation of Railways

What is to be done with the railways of the United States? Which of the several plans, proposed by men [illegible] to speak or write on the subject, shall be tried out? Discussion of this subject is desirable at this time because it is admitted that the present state of things should be changed as soon as possible. Our government has already assumed a large financial burden in the few months of its control; the relations between the administration and the employees have been far from ideal; the commercial and shipping interests have with good reason been dissatisfied with the service rendered, aside from any delays and inconveniences incident to war conditions.

A paper presented before the American Society of Civil Engineers last February by Mr. Francis Lee Stuart of New York City has brought forth some interesting discussion by railway engineers. Mr. A. J. County of New York City in his discussion of this paper quotes at length the testimony of Mr. Wm. M. Acworth of England before the Joint Subcommittee on Interstate and Foreign Commerce of the Congress of the United States, as being pertinent to the subject of Government control and ownership. The following is taken from Mr. County's quotation:

Systematic Development of French Railway System.—The railway history of France stands by itself. Nowhere is the passion for logic and the love of symmetry which distinguished the French genius better exemplified than in the history of the French railway system. The ground plan of the policy which, broadly speaking, France has followed ever since, was laid down in a law passed as long ago as 1842. There were important developments after the world crisis in 1857, and again in 1878. And on Jan. 1, 1909 the Government, by taking over one of the six great systems, the Western, upset the symmetry of the original plan. But with this exception, throughout the whole history the original plan has stood firm. The whole country was divided up among six great companies, five of which radiate from Paris and the sixth, from the Midi, serves the extreme South and Southwest. The development of the railway network has been systematic from the outset; trunk lines first, then important branches, then the less important ones, and finally in recent years a considerable development of light secondary lines. Throughout, the state has guided, subsidized, and controlled. Each company has a monopoly of its own district. So far as possible, the points where the great systems meet are arranged not as in Holland, or formerly in Italy, at the great towns, but precisely at the points of least importance from a traffic standpoint. Where traffic is unavoidably competitive, as, for instance, from Paris to Central Switzerland which can be reached either by the Eastern or by the Paris & Lyons Ry., arrangements are deliberately made to prevent competition. The Government controls all rates and fares charged and all services given, and the Government approves, not merely of pools, but of agreements by which shippers attempting to consign traffic by the route by which the railway companies have agreed the traffic shall [illegible] are deliberately penalized by higher rates.

Why the Government Took Over the Western Ry.—Among the great French companies, much the weakest financially was the Western. A large portion of its mileage was in Brittany, one of the poorest districts of the country. It did serve the town of Rouen and the very important port of Havre, but the canalization of the Seine diverted from the railway a large proportion of the valuable merchandise traffic between Havre and Paris. The French Government guarantees the dividend on the shares of all the French railway companies, and year after year the French Government had to find a considerable portion of the dividend to the Western shareholders.

Further, large new capital expenditure was needed, especially to cope with the enormous passenger traffic of the company in the suburbs of Paris. How heavy that traffic is anybody who remembers the St. Lazare Station in Paris will know. The necessary capital could not be raised without Government approval; and Government approval, owing to strong parliamentary opposition, could not be obtained. Meanwhile, the service was going from bad to worse, and the equipment was on its last legs. Something had to be done. Once more the knot that could not be untied was cut; and, as from Jan. 1, 1909, the Government exercised its rights under the concession, and took over the railway, continuing to pay the guaranteed dividend to the shareholders in the form of an annuity running until the termination of the concession.

The political history of the transfer is distinctly interesting The employes on the railway itself were unanimously in its favor; and, as subsequent experience proves, with good reason; and the whole strength of the Socialist Party and of socialist sentiment was thrown on the same side. A majority was secured for the bill in both houses, though a large majority of the representatives of the districts served by the railway voted against it. The bill passed the Chamber in December, 1906; but it was hung up in the Senate for 18 months, until June, 1908, and finally only passed by a majority of 3 votes, after M. Clemenceau, who was Prime Minister at the time, had given it to be understood that unless the bill was passed he would resign; and, much as the majority of the Senate disliked nationalization, at the moment they disliked the resignation of M. Clemenceau even more. It may further be added that, according to the French custom, the opinion of all the chambers of commerce in the country, which are statutory bodies, was invited on the measure, and that not one single town of more than third-rate importance reported in its favor.

Experience of State Operation in France.—Here in broad outline is the story of the result of the transfer. In the 5 years, 1904-08, before the transfer, the gross receipts rose steadily from $37,084,000 to $42,145,000. In the 5 subsequent years, 1909-13 (the war upset entirely the figures for 1914), the gross receipts rose from $42,333,000 to $48,701,000, a slightly greater rate of increase. In the 5 years before the transfer, the operating expenses rose from $20,796,000 to $28,388,000, this last figure being unduly inflated by the fact that, from the date the chamber voted the acquisition of the railway, the staff became entirely demoralized. The first year after the acquisition the operating expenses were $30,304,000. The next year they were $34,921,000, and the year after, $39,454,000. In 1912 they had reached $41,800,000, and for 1913 they fell back to $41,478,000. In other words, to earn a net revenue increased by 31 per cent the operating expenses increased by 100 per cent. The net revenue was never below $13,757,000 in the worst year of company rule. It fell to $5,352,000 after the Government had been in possession 4 years. The operating ratio, which had risen from 56.4 to 67.8 under the company, was for the next 5 years as follows: 72.7, 79.9, 87, 89.4 and 85.2. It is fair here to make a qualification. The operating ratio had gone up on all the French railways between the two periods. It averaged 50.3 for the other five great companies for 1905 and 1906, and 58.4 for 1912 and 1913; but a rise from 50.3 to 58.4 is one thing; a rise from 56.4 to 89.4 is quite another.

A main argument used in Parliament in favor of transfer from the company to the State was that the company never did, and never could, earn its guaranteed dividend in full, still less the extra dividend which it would be entitled to if earned; that the company was accordingly a mere caretaker, and not interested in financial results, and did not operate, and could not be expected to operate, with economy. The State, on the other hand, would have a direct interest in operating economically. That was the argument. Here are the facts: During the last 10 years of company management, the State had to pay an average of $2,894,280 a year to meet its liability under the guaranty to make up the deficiency in net operating income. During the first 3 years after the transfer, the sums it had to find, under the same head, were $6,753,320, $8,875,792, and $14,934,484, respectively. For 1912, the figure was $14,752,237.

Nor do these deplorable financial results tell the whole story. The service to the public was absolutely demoralized. There were several very serious and numerous smaller, accidents, and the staff and the public got so frightened that the express trains on the main line, already the slowest in France, were decelerated down to a timing that had been abandoned as inadequate in 1896. In addition, a number of trains were suppressed altogether. Punctuality went to the winds. Commuters on the system in the suburbs of Paris were compelled by their employers to live elsewhere because of the unpunctuality of their arrival at their work. As for the service in general, one figure will suffice. Compensation for accidents, loss and damage, averaged some $400,000 or $500,000 a year in the last days of the company. In 1911 the figure was $2,015,291.

Causes of Unfavorable Results from State Ownership.—M. Leroy-Beaulieu, the eminent French economist, gives the reasons for the "deplorable situation" as follows:

In the first place, it is the abuse of formalism and red tape, with all the delays which follow and which are directly in conflict with commercial needs. In the second place, it is the lack of stability. The director and all the chiefs of the service change at the will of the ministers, whilst in the private companies the higher personnel is maintained a long time, fulfilling the same functions. It is next the political influence which enters into the choice and advancement of the personnel. It is, lastly, the lack of discipline which also results from the political influence at work. From the electoral point of view, the lower staff, being much more numerous, will always have much more power than the superior staff. It is always on the side of the former that many deputies will be systematically ranged. Above all, it is impossible to be at once controller and controlled. If one of the great French companies under private management renders poor service, the public opinion is not slow to move the public power, and as this has the means to bring pressure indirectly but in many ways upon the companies, they are led to reform. On the contrary, when complaints are made against the State itself, the administration, irresponsible, does not listen. Rather, it seems indignant that particular individuals or even large associations should dare to find that all is not perfect.

From all points of view, the experience of State railways in France is unfavorable, as was foreseen by all those who had reflected upon the bad results given by the other industrial undertakings of the State, such as telephones, matches, and many others. The State, above all an elective administration, cannot be a good commercial manager. It works expensively, and is powerless before its employes. The experience which we have recently gained has had at least one result. It has provoked a very lively movement, not only against the repurchase of the railways, but against all extension of State industry. This result seems to me fortunate. I hope this opinion will be maintained and that not only we, but our neighbors, may profit by the lesson of these facts.

M. Leroy-Beaulieu gives examples of what has happened under the various heads. "As for formalism and red tape," on the eve of the handing over of the railway to the State there were 1,526 employes in the central office. Within three years the number had increased to 2,587. The single service of the accountant general was increased by 70 persons directly after the repurchase." And this was partly due to political pressure and partly to excessive red tape. For example, in the Caen Division, the preparation of the pay sheets which, under the company, took 9 persons 3 days = 27 days, under the State administration took 12 persons 6 days = 72 days. "According to official documents, there are not less than 96 persons receiving a salary of more than $1,929.52 in the State system" as against 33 on the system of a neighboring company of much the same mileage, but with much higher receipts. In the 5 years from 1908 to 1912 the total expenditure increased $10,573,770, of which $8,412,707 were for salaries and wages. In 1908, out of every $19.30 of receipts, the company paid $7.24 in salaries and wages. In 1912 this figure was $9.70. The comparative figure for the five great companies is only $5.70. In 1910, per $192,592 of receipts, the State railways employed 235 persons, the private companies 174.

Plan for Reimbursing Railroad Administration for Equipment Bought for Railroads.—The special committee of bankers appointed by T. De Witt Cuyler, chairman of the Association of Railway Executives, to devise a plan under which the Railroad Administration may be reimbursed for about $400,000,000 of railroad equipment which it purchased and has in part allocated to the railroads, has submitted a plan and it is now before the Director General of Railroads and his financial advisers. It provides for the incorporation of a Federal Company which shall invest $148,000,000 in 4½ per cent cumulative stock which will be liquidated in equal installments over a period of 15 years. This corporation will issue for public subscription $280,000,000 in equipment trust certificates.

Concrete Railway Track Support

Various types of concrete track construction that have been installed on American railways were described by Mr. A. C. Irwin, engineer of the Structural Bureau of the Portland Cement Association, in a paper presented June 28 at the convention of the American Concrete Institute. The matter following is taken from Mr. Irwin's paper.

Street Car Track Construction at Anderson, S. C. A type of track construction designed by Mr. E. R. Horton, Jr., and used in Anderson and Greenville, S. C., for street car track construction is shown in Fig. 1. This is in reality the longitudinal girder principle. The rails are embedded in the concrete and rest on a continuous plate. Rail clips and hook bolt anchors are used.

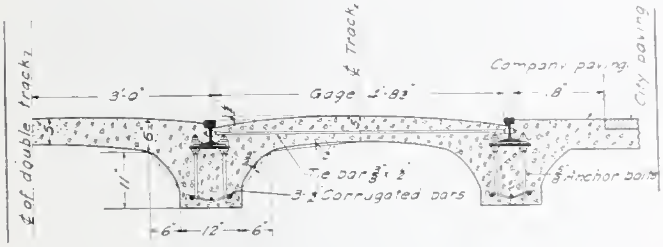


Fig. 1—Concrete Street Railway Track Construction at Anderson, N. C.

Recent inquiry in regard to the condition of this track after 4 years' service indicated that the construction has been found satisfactory in every particular, that vibration has not caused deterioration of the concrete and that even the paving between the tracks is in good condition. To adapt this design to steam railroad requirements, states Mr. Irwin, it would only be necessary to deepen the girders and widen them out at the base for additional bearing area and to change the paving in between tracks to diaphragms at intervals below the base of rails.

Installation on Long Island R. R. at Jamaica, N. Y.—Examples of the type involving a concrete slab carrying ballast in which ordinary track ties are embedded is shown by Fig. 2. This construction was placed under 49 crossings, switches and slips on the Long Island R. R. at Jamaica, N. Y. The work was put in during the winter of 1912-13 on embankments composed of sand averaging 20 ft. high. Portions of the slabs were placed without allowing time for the embankment to settle and the traffic over these slabs has been extremely heavy from the day they were put in, running as high as 1,300 train movements per day. After 3½ years the general manager of the Long Island R. R., J. A. McCrea, reported that there had been practically no maintenance on the track. Mr. McCrea goes on to say that the great advantage of the slab is that the bearing surface on the natural ground is increased about three times over the usual method without taking into consideration its continuity and that examination of these experimental slabs showed that there were no cracks, at least in the vicinity of the points of examination. It will be noted that these slabs are not reinforced and that they are only 8 in. thick. It should also be noted that they have been subjected to the pounding that occurs at crossings and frogs.

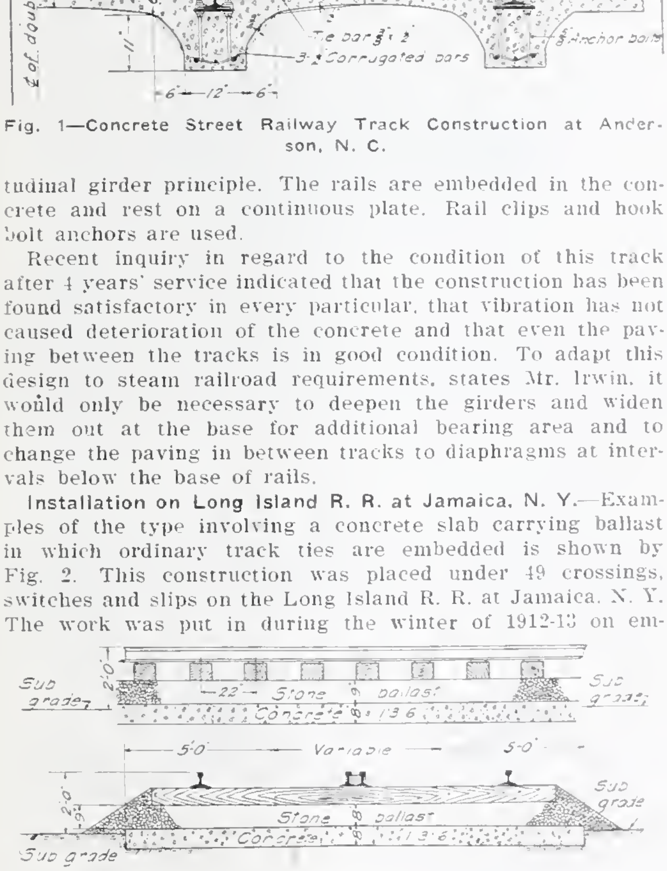


Fig. 2—Section of Concrete Slab, Jamaica Improvement, Long Island R. R.

It has become very common practice to use reinforced concrete slabs to form the decks of deck girder railroad bridges. These slabs are usually about 1 ft. thick, 5 ft. long and span the distance between girders. The ballast is retained by curbs at the ends of the slabs. The testimony of railroad officials in regard to this construction is that when the ties are once embedded they stay in place and that maintenance is very greatly reduced.

Bergen Hill Tunnel Tracks, Delaware Lackawanna & Western R. R.—The new Bergen Hill Tunnel of the D. L. & W. R. R. was completed in 1909. The tracks in this tunnel are carried on reinforced concrete slabs, details of which are shown in Fig. 3. This construction was designed by Mr. Lincoln Bush, who was then chief engineer of the railroad.

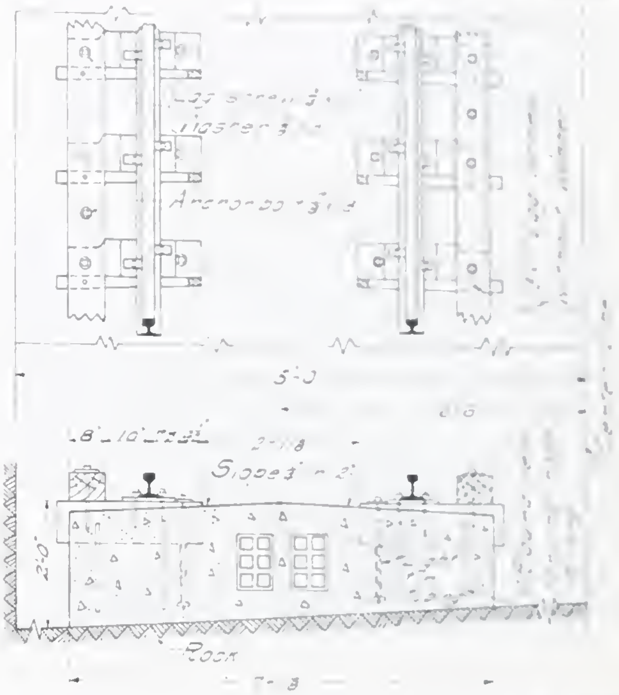


Fig. 3—Concrete Track Construction Used in Bergen Hill Tunnel of D. L. & W. Ry

Under date of Oct. 3, 1916, Mr. Bush reported as follows in regard to this construction.

"It was completed and turned over for service in February, 1909. The roadbed in the new tunnel has stood up exceedingly well and none of the creosoted tie blocks have been renewed so far as I have learned on recent inquiry.

"My idea in getting out this design was if railroad track could be made perfectly rigid and unyielding that there would be no pounding or unusual stress in rail. The roadbed in the new tunnel referred to has been in service under the heaviest kind of traffic since February, 1909, and has demonstrated fully that if track is made perfectly rigid that it will stand up against the heaviest kind of traffic.

"I am convinced that with a perfectly rigid roadbed that there will be no pounding and serious damage to [illegible] track unless some [illegible] exist [illegible] conditions, however, are [illegible] the railroad rolling stock. I [illegible] with the heavy rolling stock that the [illegible] practically reached the [illegible] is used the supports [illegible] like the abutment of a bridge [illegible] in the rails and it will be found [illegible] the stress may be greater in the rail [illegible] less stiff rail [illegible] which [illegible] flection."

Fig. 4—Concrete Track Construction at Pennsylvania Terminal, New York

The tie blocks are notched at the outer end to form a shoulder and are in place when the concrete is poured. A wedge is driven in between the concrete and the opposite side of the block, preventing the block from being disengaged from the shoulder under traffic. The blocks are replaced by removing the wedge, pushing the block longitudinal of the track so as to disengage the shoulder, and slipping it from under the rail. This work can be done by one man.

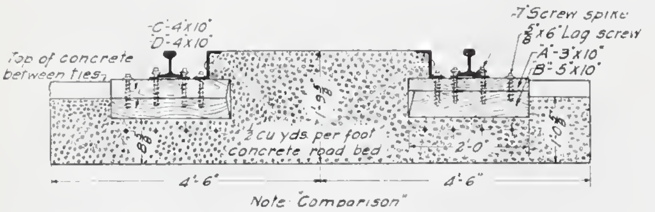


Fig. 5—Concrete Track Construction on Chicago Junction Ry.

Track Construction in Pennsylvania R. R. Terminal Station, New York.—Figure 4 shows the concrete track construction in use in the Pennsylvania R. R. terminal station, New York. A single track length of 14,600 ft. of this type was laid adjacent to platforms. In general the concrete was laid on the rock of the subgrade but where the subgrade consisted of loose rock backfilling the concrete slab was reinforced. A length of 720 ft. of similar construction is in use in two of the East River tunnels (Nos. 1 and 2) immediately east of the Long Island shafts. These sections of track are subjected to high speed traffic.

The Chicago Junction Ry. Track.—In 1911, 500 ft. of concrete track support was installed on the Campbell Ave. line of the Chicago Junction Ry. where it crosses the Illinois and Michigan Canal. Details of this construction are shown by Fig. 5. This construction is patented by Mr. Louis H. Evans of Chicago and was installed on the Chicago Junction Ry. as an experimental stretch of track, the location being selected with a view to subjecting it to very heavy and continuous traffic. A majority of the stock trains going to the Chicago Stock Yards pass over this concrete track. These trains are usually drawn by heavy locomotives and make more than usual freight train speed. A thorough examination of the track indicates that although transverse cracks appear in the portion of the concrete above the base of rails, these cracks do not extend down into the supporting slab. In fact, the construction seems to have suffered practically not at all from the heavy traffic which it has carried. Mr. G. W. Hegel, chief engineer, the Chicago Junction Ry., advises that there has been no maintenance on this stretch of track excepting to renew a few of the tie blocks. The tie blocks are spaced 34 in. centers. So great a spacing would not be allowed with the usual ballast and tie type of construction but with this unyielding track foundation such a spacing has been found to be practicable, since the majority of the deflection in railroad track is due not to the lack of rail stiffness but rather to the lack of any sort of rigid support. Mr. Evans sums up the comparison of this construction with the usual type as follows: Weight of train distributed over three times the surface saves .6 of the ties. The cost for 20 years is one-fourth of rock ballasted track.

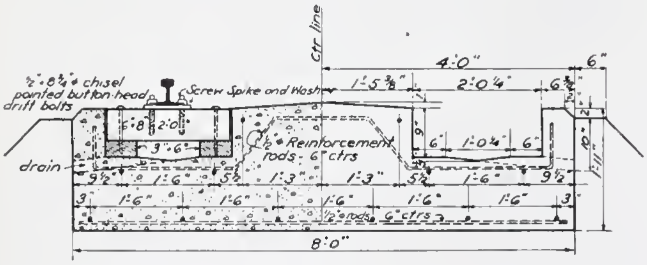


Fig. 6—Type 1 of Northern Pacific Ry. Concrete Foundation.

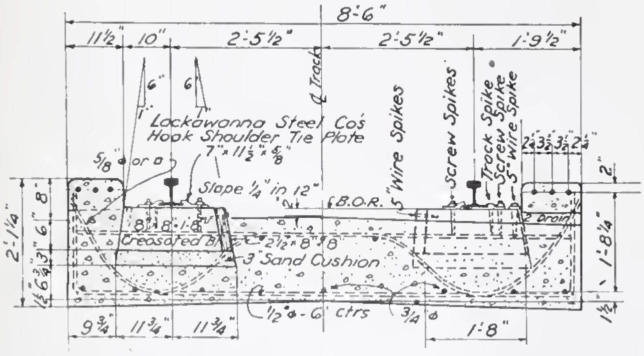


Fig. 7—Type 2 of Concrete Foundation on Northern Pacific Ry.

Northern Pacific Ry. Track.—On the Point Defiance Line of the Northern Pacific Ry. in the State of Washington, there was constructed about 5 years ago, 2,000 ft. of track with a concrete slab foundation. Details of the three types used are shown by Figs. 6, 7 and 8. In general, these types consist of a reinforced concrete slab provided with recesses or troughs for the reception of wood blocks or stringers to carry the rails. Details of Type No. 1 are shown by Fig. 6. The short tie blocks rest on two longitudinal 3 by 6 pieces in the bottom of a trough at each side of the slab. The space in between tie blocks is filled with ballast. Drainage of the troughs is provided at intervals. There is a total of 594 ft. of Type 1 construction. The slabs are cast in lengths 16 ft., 5½ in.

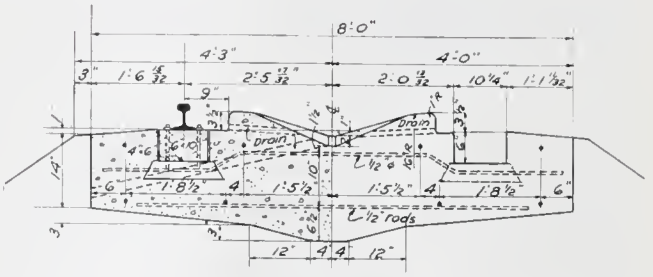


Fig. 8—Type 3 of Concrete Foundation Used on Northern Pacific Ry.

Type No. 2, Fig. 7, is 6 in. wider than Type No. 1 or No. 3, and is distinguished by a curb practically equal to height of rail along each side. There is also 594 ft. of single track of this type in service. In this type recesses are cast into the slab into which the tie blocks are placed and wedged into position. The rails are fastened in the usual way with tie plates and screw spikes. In the bottoms of the tie block recesses 3 in. of sand is placed to afford a cushion. In top of this sand cushion the creosoted tie block is placed and wedged at the inner end of the block. L-shaped malleable iron shims are used at the other end of the tie blocks with one leg of the L resting on top of and fastened to the tie block. This allows lining and gauging of track. These slabs are cast in widths of 32 ft., 11 in.

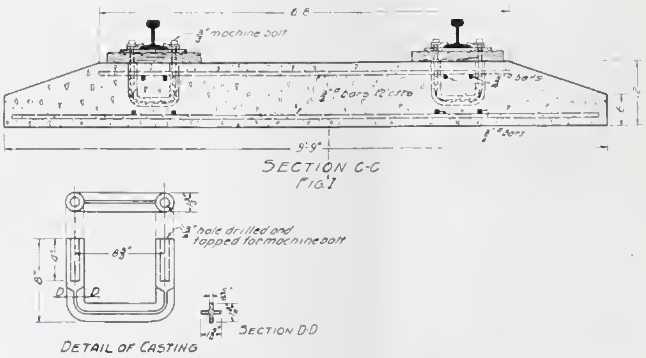


Fig. 9—Design of A. D. Whipple and A. C. Irwin for Concrete Track Support.

Type No. 3 is shown in detail on Fig. 8. The distinguishing features of this type are that the concrete is carried up 3½ in. near the inside of each rail and sloped to center of track for drainage, and that the rail rests directly on a continuous longitudinal stringer of 6 by 10 in. creosoted fir. These stringers are fastened at intervals by long lag screws driven into wood anchor blocks embedded in the slab. The slabs have a depth of 18 in. at the center and were moulded in lengths of 16 ft., 5½ in. There is a total of 810 ft. single track of Type 3.

While neither the first cost of the concrete track foundation on the Northern Pacific R. R. nor the annual maintenance cost of it are available, yet the railroad company's officials say that the maintenance has been far below that of track of the ordinary type of construction on the same line. The greater part of this maintenance concerns the wooden blocks to which the rails are fastened especially with Type 3. In this type the key blocks out in spite of the fact that they are spiked to the tie blocks.

New Design for Concrete Track Support.—Figure 9 shows a suggested design for concrete track support prepared by Mr. A. D. Whipple and Mr. Irwin. The form work required for this slab is of the simplest sort. The design of the slab is based on Cooper's E-60 loading with 100 per cent impact. This design does not require any radical departure from the usual type of rail fastenings, that is, a rail clip is used similar to those now standard. There is, however, a very great difference between this rail fastening and the usual cut or screw-spike used with wooden ties. In this concrete design a U-shaped casting is embedded in the concrete and the upstanding legs of the U are tapped to receive the threaded end of holding down bolts which pass through the rail clips, tie plate and tie block. A positive fastening which has great strength against lifting the rail is thus secured. The use of a block of wood under the rail in this design is at once a concession to the prevalent idea that some elastic medium must always intervene between a track rail and a solid foundation and a means for easy adjustments of the rail both vertically and horizontally to provide for whatever inequalities may exist in the top of the slab either at the time of placing or subsequent thereto. The latter is the only sufficient reason for using this tie block, and where the slab is placed on a well compacted subgrade the rail may be anchored directly to the concrete, with possibly the intervention of a longitudinal steel plate between the rail and the concrete surface, thus affording the rail a continuous support. In the latter case drainage would be taken care of by finishing the slab to a slight pitch between the rails and furnishing openings beneath the rails at intervals.

Method of Blasting Green Stumps

In blasting green stumps it is desirable to use a blasting machine and electric blasting caps. This enables the operator to place his charges at several vulnerable points under the stump and to fire them all exactly together. This is impossible when cap and fuse are used. First, use a thin steel probe with sharp point to locate the main roots. Locate one charge under each of these main roots placed a few feet out from the trunk of the tree. This places the main lifting charge directly under the center of the trunk, leaving from 1 to 4 ft. of earth between the stump and the charge. If it is a large stump 5 to 8 ft. in diameter, the main lifting charge should be down about 4 ft. If it is a small stump of 12 or 18 in., 1 to 2 ft. will be sufficient. When it is necessary to use more than two cartridges for the main lifting charge, a half cartridge should be fired in the bore hole first to make a little pocket into which a larger charge may be loaded. Time should be given for the pocket to cool before loading it.

The size of the charge depends upon the size of the stump and the nature of the soil. For a green stump of 3-ft. diameter in a dense, moist soil, about 8 lb. of dynamite will be required. If the soil is loose and dry, 12 to 14 lb. would be nearer the correct charge.

If the charge is 8 lb. and there are three main roots, it would probably be best to load about 5 lb. in the deep hole under the center and place 1 lb. in each of the holes under the three roots. If the charge used is 12 or 15 lb., it can be apportioned in about the same ratio.

Whatever the charge, it is important that the tamping should be as tight as possible. The better the tamping, the less dynamite, is the general rule.

It is difficult to tamp dry loose soil. Pour water down the bore holes, if possible, and use wet though stiff tamping material. Aim to make the soil as compact as it was before the bore holes were put down and in case of loose, sandy soil, even more so.

Of course, the charges should be connected up in series by means of the blasting cap wires before the blasting machine is operated. If the charges are fired one at a time even with a blasting machine, no better results are obtained than with cap and fuse.

How to Reduce Risks in Earthwork*

BY HALBERT P. GILLETTE

Editor Engineering and Contracting

Few classes of construction are so difficult to control economically as earth excavation. Rains or freezing weather may completely upset the best laid plans and cause a severe financial loss. Usually most of the working gangs are common laborers, quite irresponsible, quitting at the slightest provocation, often with no provocation.

The character of the earth itself may vary greatly from week to week or even from hour to hour. The length of haul is seldom constant even for one day. Small wonder, then, that no ordinary class of contracting is more hazardous than earthwork.

Experience and Work Necessary in Estimating.—The first great risk is taken when the estimate is made as to the classification of the excavation. Here it is that experience counts so much in favor of an older man, and lack of experience hits a younger man so hard. But a young contractor is not necessarily without means of self-protection. He can employ an experienced superintendent, he can dig test pits and make earth soundings.

When I first went into the contracting business, I soon learned never to bid on excavation until I had "prospected" the job pretty thoroughly. It is surprising how much can be accomplished in a short time in this manner.

Sounding with rods is an expeditious way of ascertaining the depth to ledge rock or to hardpan, and it will also disclose the existence of boulders. But in an unfamiliar country, it often is necessary to dig test pits or small wells, so that the toughness of the earth can be judged by observing the resistance to a pick.

Often there is insufficient time to prospect the ground thoroughly. Then, if the work is in a section where your experience has been limited, don't bid at all if the earthwork is extensive.

Prospecting for Facts.—Some years ago, a firm of young contractors in New York City asked me to assist them in estimating the cost of a large job of excavation in New York State. The cuts and fills were heavy, and the engineers had made no soundings. The engineers had estimated that the excavation would be 75 per cent solid rock and 25 per cent earth. After walking over the line, I asked one of the contractors what he thought of the "three to one" classification the engineers had made. He replied that it seemed to be "any man's guess," but that he presumed the engineers were approximately right as they had been engaged for months on the surveys and in planning the construction. Had he known more about common engineering practice, he would have had little faith in that guess as to classification. I explained to him that about the last thing that the average engineer does on such a survey is to estimate the classification, and that then he usually guesses, often wildly. "Well," said the contractor, "we want to bid on the job and it's too late now for us to do more than guess also." He was surprised when I assured him that in the two days remaining before the bids would be opened, we should be able to estimate pretty accurately what percentage of the excavation was solid rock. Since many of the cuts were [illegible] to 60 ft. deep and quite long, it looked like an impossible job to do much sounding in two days; as for adequate test pit sinking, that was impossible.

Jutting from the surface of the earth at frequent intervals was rock (gneiss) that appeared to be ledge rock and it was this appearance that had led the engineers to estimate 75 per cent solid rock. I pointed out to the contractor that ledge rock in southern New York State is usually grooved in a north and south direction as a result of the grinding action of ancient glaciers, but that none of the outcropping rocks that we had seen on that job were grooved or scratched in that regular manner. Hence they probably were boulders. There were other geological facts that led me to the same conclusion, but it remained to prove the inference beyond doubt.

I had noticed along the line several wells that supplied water to farmers, and these, I believed, would be rather deep dug wells—real test pits for our purpose. We were able to find the men who had dug some of these wells, and to learn from them that they had dug 50 to 80 ft. without striking solid rock, and that they had encountered few boulders.

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*From the July issue of Successful Methods.

In order to confirm this testimony, we put several small gangs of laborers at work sounding with rods. The results of that sounding showed that there was no ledge rock at all in any of the cuts. The subsequent excavation proved this conclusion to be substantially correct.

Naturally these contractors bid a fairly stiff price on earth and very low on rock, and were the lowest bidders.

Adequate Plant Reduces Weather Risk.—In estimating both the classification of excavation and the toughness of the materials, any nearby cuts should be examined; and local men who have done any excavation should be interviewed.

Having secured the job, it is important to reduce the bad weather risk by starting excavation as quickly as possible, and by using enough plant to rush it through before the autumn rains start. Here it is that the inexperienced contractor is apt to err. He may not order all his plant until he signs the contract; then he usually orders neither enough plant nor spare parts. Delays occur in getting the plant on the job, and several weeks of good weather may be lost before the work is going "full swing." Even then the "swing" is not "full" enough because of pennywise attempts to save money on plant investment.

I recall that a certain contractor on the deepening of the old Erie Canal in 1896 made a profit where his neighbor contractors lost money, simply because he bought, begged and borrowed a lot of equipment so that he was able to finish before the ground froze.

Have a liberal surplus of plant capacity, for surplus plant is the best investment on an earth moving job.

Fit the Plant to the Job.—The next important risk to eliminate is the risk of using a relatively uneconomic method or machine. There is no better way of reducing this risk than by having daily, weekly and monthly reports of the yardage moved by each gang. This is often not so easy of accomplishment as it sounds. Usually the only practical way of estimating the daily yardage is by counting the loads; but loads may vary considerably in size, and it may not be easy to keep tabs on the number of loads.

Carloads and wagonloads vary because of differences in the kind of earth, differences in the resistance to traction, difference in attention given to the loading, etc. Study every cause of variation in size of loads with a view to learning how to estimate the "place measure" size of a load under given conditions.

Estimate Yardage Accurately.—Your own estimates of yardage based on the count of loads should be compared with monthly cross-section estimates made by engineers. Do not think the engineer is necessarily wrong because his monthly estimate is far below your estimate. Perhaps your "tally" is wrong. More probably you have estimated too liberally as to the size of the average load. Buy 2 mechanical counters or "tally machines" for use at the pit and dump.

My brother, W. A. Gillette, has devised a satisfactory method of estimating the daily yardage handled by drags, fresnos and wheelers. A timekeeper on horseback rides from gang to gang, spending about 20 min. at each gang, during which time he counts the number of scraper loads moved by the gang. Three or more such counts are made every day for each gang, and upon these counts is based an estimate of the yardage excavated each day by every gang. The accuracy of this intermittent timing method of estimating yardage is astonishing. The engineers' monthly estimate seldom differs more than 5 per cent from the estimate thus made by the timekeeper. The great merit of such daily estimates of yardage consists in showing at once the relative efficiency of different methods, machines and men.

Compare Labor Costs with Machine Costs.—I have mentioned the unreliability of most common laborers on grading work. This unreliability, coupled with the high wages now paid to common laborers, is leading to a greater use of machinery than ever before, even on small jobs. In China, with wages at 15 ct. a day, machinery could seldom compete with hand work, for the interest, repairs and depreciation on the plant alone exceeded the cost of doing the work by hand, in most cases. That is one extreme. At the other extreme we now have Amrican unskilled labor getting 30 to 60 ct. an hour, the average being about 40 ct. Skilled labor has risen about 60 per cent in price as compared with a rise of about 100 per cent for unskilled labor. Machinery has not risen in price as much as skilled labor, and excavating machinery grows better every year. Hence it is that nearly all of us must revise our pre-war ideas about the use of machinery.

High wages lead inevitably to a greater use of machinery. This has long been evident on the Pacific Coast where contractors found it profitable, long before the war, to use more machinery than was customary in the Central, Southern and Eastern States. Wages on the Pacific Coast averaged about $2.50 a day for common labor prior to the war, whereas $1.75 was the average in the East. That difference alone justified the greater use of machinery in the far West. Is it not clear, then, that with common labor wages double what they were five years ago, there must be a greatly increased use of machinery in construction work?

Hereafter the slogan of the far-sighted contractor will be: More power and less muscle; fewer men and greater hustle.

Repairing Manganese Special Track Work by Welding With Electric Arc

All classes of worn and broken manganese special work are repaired with satisfactory results and with a large saving in labor and material, on the Montreal tramways, as described by Mr. Julian M. Scott in a recent issue of the Electric Railway Journal.

In the fall of 1916 the diamonds of a 90 deg. double track cast-manganese crossing were found to be practically worn out; all the floors were broken through and most of the corners missing. The usual method of rebuilding floors and corners was applied and with a small amount of filling done periodically this crossing will be kept in service until at least 1921. For the 5 years these repairs will have deferred an expenditure of $6,000 and made a net saving of $5,500 on interest and depreciation charges, at a cost of less than $200.

Another valuable and highly successful class of repair is that of replacing pieces broken from the tread and other portions of switches, mates, crosses, etc. In this same class might be included the building in of badly cupped ends on these same pieces.

Sometimes a perfectly good mate is found with a large piece of metal shelled out. Ordinarily this mate would have to be immediately scrapped, but in this case it was returned to full working life, as indicated in the next illustration.

The points of frogs and mates when worn short and off center are readily replaced. Switches and mates on which the bulk of the traffic takes the curve, become worn low on one side, causing derailments, etc. This trouble can be mitigated for a time by grinding, but before long the only cure is replacement. The trouble is remedied by building the tread up to the original height and shape.

To illustrate the saving, the following figures are an approximation of the value of such work to this road during 1918. All figures are based on the assumption that the life of each piece of special work is prolonged one year, thus deferring expenditures and earning the depreciation and interest charges. No allowance is made for pieces saved from the scrap pile and returned to remaining working life.

526 pieces of special work treated representing a value of...	$159,000
Interest for one year on the deferred investment at 6 per cent	9,540
Depreciation at 12½ per cent per year	19,875
	$ 29,415
Total cost of the work—all charges included	1,200
Saving effected	$ 28,215

This is a very substantial saving and proves beyond question the value of repairing special work.

Special work of the hard-center type is treated in exactly the same manner and with equally satisfactory results. The method and materials are of the simplest. When building in large breaks or holes, the first material used is bare ¼-in. round common mild steel electrodes. The wearing top is built on with bare ¼-in. round electrodes of low-grade tool steel having a carbon content of 0.85 to 0.95, which has proved to be good material at a reasonable price. The current is kept at the lowest point which will give proper fusion, and is about 140 amp. at 30 to 40 volts across the arc. No welding operations are ever carried on at 250 volts, and the standard resistance welders deliver about 70 volts, which will give 35 to 40 volts across the arc.

World Is on Higher Price Level.*

By T. S. HOLDEN.

Investigator Economics Section, Division of Public Works and Constructive Developments, U. S. Department of Labor.

What Are "Normal" Prices and Wages?—In our capacity as buyers of commodities we have proceeded on the assumption that it was desirable for prices to fall. Falling prices rarely stimulate business. They usually stimulate waiting for further declines. A period of falling prices is usually a period of business depression. The past 6 months has been remarkable for the small number of business failures. It is entirely possible that a sharp decline in prices might have been accompanied by a greater number of business failures than there has been, attended with a much greater menace of unemployment. A financial panic might have been within the bounds of possibility.

Many of those who have been deferring building projects and the resumption of production of commodities have stated that they were waiting until prices and wages should have returned to "normal." The word "normal" has been used extensively in this connection and most of those who have used it have not appreciated the true meaning of the word. Not only in connection with prices and wages has this term been used incorrectly, but courts and public utility commissions have used the term losely when speaking of valuations of properties. It is worth while to determine just what this word means in connection with prices, wages, and property values, not in the interest of accademic precision but simply to aid clear thinking on this subject.

A paper entitled "Appraisals and Rate Making" was read on March 20 at the annual meeting of the Illinois Gas Association by Mr. Cecil F. Elmes, an eminent engineer. In this paper Mr. Elmes presented with the utmost clarity and force, certain aspects of the price situation as affecting valuations of public utility properties and the principles of rate making. In the course of his discussion Mr. Elmes dwelt at some length on the misconception of the term "normal." He presented curves showing the fluctuations of prices in England on five basic articles: wheat, iron, lead, cattle and sheep, covering a period of six centuries. He also presented curves showing fluctuations of artisans' wages, both in terms of money and in terms of the quantity of wheat the wages would buy, covering the same extended period. He pointed out that in the case of each one of these curves the fluctuations are so erratic that it is impossible to draw a horizontal straight line, an oblique straight line, or a mathematical curve which could in any sense serve as a median about which the prices or wages fluctuate. Consequently it is not possible to define mathematically in terms of past experience the "normal" price of a given commodity, or "normal" wages. Neither is it possible to thus define a "normal" rate of increase in prices or wages.

Not everyone has the opportunity to consult the records of the British museum, as Mr. Elmes has had, for the purpose of studying this subject. There is, however, another authority which is readily accessible to all, Webster's Dictionary. Webster defines the term in connection with economics as follows:

"Pertaining or conforming to a more or less permanent standard, from which, if the individual phenomena deviate on either side, such deviations are to be regarded as self-corrective. Thus, in economics, the normal price is a price which corresponds to the cost of production."

Relation of Price and Cost.—The standard to which a price must conform is, therefore, not necessarily a price that we are accustomed to or that we were accustomed to 5 years ago. Mr. Elmes has shown that past experience has established no mathematical standard to which a price may be expected to conform. Webster says that the standard is the cost of production. In 1919 the standard is the cost of production in 1919, and not the 1914 cost of production. There is no justification for assuming that $12 is an unfair price for a pair of shoes today simply because the same pair of shoes might have been bought in 1914 for $6. The only criterion for the present price of shoes is the present cost of production of the shoes plus a reasonable margin of profit to those concerned in the making and the selling of the shoes.

Similarly "normal" wages [illegible] conform to the wage scale of 1914. "Normal" wages in 1919 must cover the cost of living in 1919 with a reasonable margin.

Similarly, the fact that the customary street car fare in the past has been 5 ct. is not necessarily an indication that a 5 ct. fare is the "normal" fare in 1919. As in the case of prices and wages, the standard of the rate to be paid for the services rendered by any public utility corporation is not fundamentally the rate the public has been accustomed to pay, but the cost of production of the commodity that is being sold, whether it be gas, electric power or transportation.

It is also true that the normal valuation in 1919 of any piece of property, whether it be improved real estate or a public utility is, fundamentally, the total cost of reproducing of that property under the conditions of material prices and wages in 1919.

Purchasing Power and Value of the Dollar.—Another element of confusion has arisen in the minds of some by the attempt to draw a distinction between the purchasing power of the dollar and the value of the dollar. It has been stated that the purchasing power of the dollar measured in commodity prices has been cut in half, but the value of the dollar, which should be measured in terms of the wealth of the country, consisting of real and personal property, has not risen. On the basis of this distinction it was argued that prices must fall in order that the purchasing power of the dollar might become commensurate with the value of the dollar. It appears to be an economic fallacy to draw such a distinction. John Stuart Mill defines value as follows:

"The value of a thing is its general power of purchase, the command which its possession gives over purchasable commodities in general."

In other words, the value of the dollar is the purchasing power of the dollar. Furthermore, contrary to the argument outlined above, prices have remained high and rents and property valuations have been increasing since the time the statement referred to above was made.

The owner of a house and lot may state to the tax assessor that the value of his property is $10,000. In making a statement of his assets and liabilities for the purpose of securing credit he may place the value of his property at $15,000. In his own mind he realizes that these valuations are more or less fictitious, though perhaps justified by custom. However, if he knows that the price which he can get for the property is $12,000, he knows that the actual value of the property is $12,000.

In connection with valuations of public utilities and the fixing of rates, although the basic principle which applies to the price of commodities and wages of labor and valuation of real estate constitutes the standard of normality, it is fully realized that, in practice, restrictions, legal and otherwise, operate to modify the application of this principle. However, it is evident to all that so long as these properties are owned and operated by private interests the returns must ultimately be in proportion to the cost of production of that which is sold to the public. When operated by the public through Government officials, if the rates paid for the service are not sufficient to cover the costs, the deficit has to be paid out of public funds.

It has been pointed out above that the curve for the fluctuation of prices of any particular commodity covering a long period of years, is so erratic that it is impossible to derive from it either a "normal" price of the commodity or a "normal" rate of increase in price. However, if the curve representing the average of prices of a great number of basic commodities be drawn, the fluctuations are much less marked than those of any particular commodity.

Prices and productions costs, which constitute the norm of prices, are measured in terms of money. Wages and the cost of living, which is the norm of wages, are measured with the same yardstick, money.

A chart, covering a period of 40 years in the United States, shows that the curve of the price index for basic commodities keeps very close to parallelism with the curve representing the stock of legal tender in the country.

Early in March Professor Fisher's paper entitled "The New Price Revolution" was published by the Department of Labor. Owing to the fact that this was probably the first announcement to the public that prices would not fall, the statement contained in the paper commanded universal attention. This paper pointed out as the cause of the new price level the increase in the amount of money and credit instruments in the civilized world.

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*Abstract of prepared testimony submitted to the Public Utilities Committee of the Chamber of Commerce of the United States.

Professor Fisher's statement was followed a month later by a bulletin of the Division of Public Works and Construction," Development of the Department of Labor," which briefly summarized all those facts concerning the records of foreign prices during the war period, the experience of the Civil War, and the war history of prices of basic commodities in this country, which had a bearing on the present situation. These facts were strictly in accord with Professor Fisher's announcement.

Present Price Level Accepted by Public.—During the past few months there has been evident a growing tendency on the part of the public to accept present prices and to wait further only for some assurance that prices would not fall.

The investigating committee appointed by the Illinois State Legislature in its report published May 6, stated definitely that all the facts it had learned concerning wages and production costs and prices were in accord with the theory that a new price level had been established. As evidence of its complete acceptance of this fact, the Legislature immediately authorized the letting of contracts for 650 miles of roads.

The growing volume of building operations throughout the country indicates that the public has largely given over its policy of waiting. The Department of Labor is daily in receipt of statements from leaders in business and finance attesting the correctness of the statements it has published concerning prices.

The Federal Reserve Bulletin for May states:

"The underlying and most general factor tending to sustain the present high level of values is the credit and banking situation, inflated as it is throughout the world. So long as the condition of inflation referred to continues to exist as at present it must be expected that reductions of price will occur slowly as a result of changes in the demand for and supply of commodities. This will in some cases bring about reductions in the levels of values, but in others will produce corresponding and offsetting variations in the opposite direction. Prices will thus be subject to temporary oscillations, but in order to bring about any broad and far-reaching readjustment affecting the relationship of all commodities to the unit of purchasing power, inflated credit conditions must be eliminated, and the business community must be placed upon practically the footing in relation to credit and money which it is normally to occupy."

One of the factors that has tended to delay building operations has been the tendency on the part of bankers to refuse advances of money on the basis of valuations computed in terms of present prices of materials. It is hoped that the statement of the Federal Reserve Board will influence the bankers to pursue a more liberal policy.

Maximum Level of Prices Not Yet Reached.—According to figures of the Bureau of Labor Statistics the maximum level of wholesale prices of basic commodities was reached in September, 1918, the index figure being 207. This figure is based on the average for the year 1913 as 100. The index figure for the month of February was 197, for the month of March it was 200, for the month of April it was 203. Weekly quotations continue to show more commodities advancing than declining. Thus it is seen that the price level is again within hailing distince of the maximum. The question today is not whether prices will fall or how much they will fall; it is rather, how much higher will they go? The principal commodities that have advanced recently are foodstuffs. Although there is a surplus in this country, there is a world to be fed; and the world supply is short. Mr. Herbert Hoover has been quoted as stating that wheat would probably go to $3.50 a bushel if all restrictions were removed. The cost of living is still increasing and the dollar is still on the decline. The problem is to arrest this decline in the purchasing power of the dollar.

People want to know today what future prices are likely to be. It is impossible to prophesy, but it is possible to view facts that will have a bearing on future prices. From these facts it may be possible to indicate future price tendencies.

It took 13 years after the Civil War for wholesale prices to get back to the prewar level. The circumstances of that period were much more favorable for price reductions than they appear to be at the present time. As compared with the war just ended the Civil War was a purely local affair.

The reason why the present situation has been so difficult to understand is the fact that it is a world-wide phenomenon. The scope of the economic changes has been as wide as the war itself. In January of this year the Bureau of Labor Statistics' Index figure for wholesale prices of all commodities showed an increase of 102 per cent over the year 1913. At the same time the price level in England was 117 per cent higher than in 1913; in France it was 249 per cent higher. It is a significant fact that France, which showed such a marked rise in the price level, resorted to inflation to a much greater extent than did either England or the United States. In England and in America it has been considered wise to pay a large proportion of the expenses of the war through the levying of heavy taxes, thus minimizing the necessity for extension of the public debt and the inflation of currency. In those countries where it was considered expedient to avoid high taxation and to resort to inflation the people are now paying the piper through the high prices they are obliged to give for the necessities of life.

Whether you believe with the majority of economists that the price level is the result of the amount of money, or whether you agree with the minority that the quantity of money accommodates itself to the price level, the present condition of world-wide high prices accompanied by a world-wide increase of money and credits must be considered. Either prices in the future will be less because of a contraction in the amount of legal tender, or lower prices in the future must be accompanied by a decrease in the amount of legal tender. Hence the problem of future prices depends upon the solution of the financial problems and a solution of that can not be wholly controlled by any one country.

Lord D'Abernon, an eminent British financier, has been quoted as follows:

"If there were to be any attempt today to bring about a rapid return to the gold currency basis of 1914 it would almost double the weight of the world's indebtedness and would certainly lead to the bankruptcy of many nations. The governments which have borrowed cheap money would, in the case of contraction, have to repay with dear money. Individuals who have borrowed cheap money would have to pay back with dear money. It is extremely unlikely that the Governments of the world can be reasonably expected to decrease appreciably the world inflation within a brief period of years."

Condition Not to Be Avoided.—The conditions that have brought about inflation and the rise in the price level in this country could only have been avoided if all trade relations with Europe had ceased at the outbreak of the war. What has happened has been that we have shipped enormous quantities of goods to Europe. These goods have not been used in production, but have been consumed or destroyed. We have received in return, not goods, but money. These transactions, in the aggregate, have approximated $15,000,000,000. Before the war this nation was indebted to Europe to the extent of $6,000,000,000. We are now Europe's creditor to the extent of $9,000,000,000.

A serious problem at the present time is concerned with the conditions surrounding future trade relations with foreign countries. If America continues to ship goods to Europe, receiving in return only money or promises to pay there is danger that the disparity between the amount of commodities and the amount of money in this country will continue to grow, resulting in a level of prices even higher than that obtaining at the present time. In view of this, some people think today that it may become advisable to restrict exports to such an extent that they may be paid for in commodities rather than in money. Such a regulation could scarcely be put into effect all at once. It might not be practical at all. It would appear, however, that Europe's debt to us must ultimately be paid in goods.

Any consideration of future prices must necessarily involve a consideration of the probable tariff program. Without going into the controversial aspects of this subject, it is well that these phases of it which are likely to affect prices be noticed here. It is a serious question whether it is desirable that a tariff schedule be framed in such a way that we shall continue to ship goods away and receive in return only money or promises to pay. What used to be considered a favorable balance of trade, may not be considered so favorable in the future. The ideal condition in foreign trade is the exchange of commodities for commodities, money being used merely as that which facilitates the exchange. It is true that it would not be desirable to have foreign goods sold in this country in such a way as to demoralize our markets. It is none the less true that we do not want further increases in our stock of money to such an extent that its purchasing power will continue to decline.

This problem is engaging the serious attention of some of the best informed leaders in business, economics, and statecraft. It is to be hoped that their reasoned opinions will have a great influence on our future tariff policy. Even though past tariff policies may have been successful, any new policy must be framed after thorough consideration of a large body of new facts. A wise program can not be expected if it is made solely as a compromise between the claims of short sighted, selfish interests. It can not be expected if the problem is viewed only in the light of before the war.

There are many far-sighted, thoughtful men among our leaders of business and our public men. There are men expert in this intricate subject among our practical economists. It is to be hoped that the ideas of these groups will prevail.

Although foreign trade relations have been so largely responsible for the conditions we face at present, and though these relations may be of great importance in the future, it is possible to concentrate too much upon the problems they involve. These problems can not be settled at once. France has been obliged to await the settlement of the Peace Treaty, and has deemed it expedient to place drastic restrictions on imports during the waiting period. Great Britain has raised the barriers against foreign goods for the duration of such time as is necessary to get her industrial house in order. The period of readjustment in Europe must be necessarily prolonged.

In the meantime, should the people of the United States sit idly by and watch their dollars shrink? Must prosperity wait until foreign markets are opened to us? When the wheels of American industry are turning and every able-bodied worker has a job that brings him a substantial wage, there is a pretty extensive market for American goods among the 110,000,000 people of America. The best way for Americans to set about arresting the shrinkage of the dollar is to produce more goods, thus remedying the existing disparity between commodities and money.

Prices of Building Materials Likely to Increase.—The nation's shortage has been estimated at 1,000,000,000 houses. At the beginning of the year the building of homes was urged on the grounds of patriotism. At present, it is an absolute necessity that they be built to fill an urgent need. Furthermore, in the light of present information concerning prices, it can be shown that money spent on building is money well invested.

Considered in relation to prices prevailing in the year preceding July, 1914, building materials are cheaper now than most other commodities. By the end of 1918 lumber had advanced 73 per cent above the pre-war level; mill prices on Portland cement had risen, on the average, 74 per cent; f. o. b. plant prices on mineral aggregate (sand, gravel and crushed stone) had risen, on the average, 73 per cent; building stone, on the average, 64 per cent; common brick, 92 per cent. The building materials group (not including any metal products) rose 84 per cent. Compare this with a rise of 113 per cent in all other commodities, and with a rise of 116 per cent in the group of farm products. The cost of construction of buildings on the average has increased about 62 per cent.

Little evidence is in sight pointing to a decline of prices in general. There is even less likelihood of declines in prices of building materials. The index for the group was the same for the first quarter of this year as for the last quarter of 1918. Slight declines in some materials have been offset by slight advances in others. As a group the prices have been practically stabilized.

In the nature of things, prices of building materials fluctuate less than the prices of those commodities which are consumed from day to day, such as foodstuffs and textiles, and of those commodities such as the metals, which furnish the raw materials of industry. During the Civil War building materials advanced less rapidly than did other commodities and they failed to reach the high levels of other commodities. In fact they remained above the general level of all commodities until 1874. If building materials, instead of increasing in price, had declined from the high point of January, 1865, at a uniform rate of four per cent per annum until 1874 they would have reached their actual 1874 level, which was the same as the general level of all commodities for that year.

A decline of 4 per cent per annum in prices of materials would probably not involve an annual depreciation in value of a building of more than $2\frac{1}{2}$ per cent. The fact is that present conditions do not indicate that the next few years will see declines in building material prices amounting to as much as four per cent a year. It is more than likely that building materials, on the average, will not decline at all for a considerable period. Present indications are that building materials are more likely to be somewhat higher on the average in 1920, than at present, rather than lower.

Not only is the demand for houses imperative and the cost of construction cheap in proportion to prices of commodities in general, but there is every prospect that the return to those who invest in building now will adequately cover present construction costs.

Rents and Property Value.—Rents and property values have, naturally, been slow in adjusting themselves to the new price level. It was reported at the beginning of the year that in 52 cities rents on the average have increased 105 per cent. In some cities they had increased 40 per cent to 50 per cent. That was merely the beginning. Rents have advanced everywhere since January, and real estate valuations have advanced in proportion to the advances in rent.

Placing cots in churches is only a temporary measure of relief. Appointing committees to investigate rent profiteering may ameliorate the inconveniences of the adjustment to new rent levels. Perhaps some people have profited by the situation who have little claim in justice to the profits. Adjustments to new economic conditions are not always accomplished easily. The only practical solution of the problem of the shortage of housing facilities is the building of houses. The ultimate solution of the problem of high rents is the resumption of all business activities to the extent that the tenants can earn enough money to pay the rents.

There is little likelihood that the building of new houses will cause rents to decline, for the rents on the new houses will have to be adjusted so as to give an adequate return on the amount invested in the new buildings.

Not only is the need for building actively pressing. Scarcely second to this need is the necessity of making many repairs and improvements in our various systems of transportation and other public utilities.

The problem of the railroads is being carefully studied by railroad men and public officials. The owners of other public utilities are asking the public, through its duly constituted officials, to grant them relief from the unfavorable conditions under which they have been operating.

The public has a right to expect that its servants will safeguard its proper interests in whatever adjustment of rates is made. The owners of public utilities have equally a right to expect the public officials to take into consideration operating conditions and costs that prevail in 1919.

Detroit Street Railway Builds Large Crusher Plant

In an effort to effect large economies the Detroit United Railways placed in operation last year a crusher plant for the production of concrete aggregate and ballast. It was estimated that about 25,000 cu. yd. of the latter material would be needed in a normal year for the construction and maintenance of interurban lines. It was believed that 17,000 cu. yd. of this could be furnished from salvaged waste material such as broken concrete, old brick and paving material which formerly had been for the most part hauled to a dump and used for filling in. The Electric Railway Journal, from which the above figures are taken, states that practically all the material crushed is waste material and is used for interurban track ballast. One foreman and three men operate the plant and with dump cars can handle [illegible] cu. yd. per day.

Commercial Sizes of Crushed Stone

Early in 1917 the Bureau of Public Roads began a survey of crushing plant practice for the purpose of securing data to be used in the development of a system of standard sizes and uniform nomenclature of crushed stone products. The 1917 survey covered plants in the New England and the Middle Atlantic States. During the summer of 1918 this work was extended to the states of Ohio, Kentucky, Tennessee, North Carolina and Georgia. The results of the 1918 survey are described by Mr. F. H. Jackson, and Mr. C. W. Mitman, in "Public Roads," from which the notes following are abstracted.

Plants Visited.—Of the 65 stone crushing plants inspected in the last field season, 34 are located in the western half of the state of Ohio and extend from the edge of Lake Erie southward to the Ohio River. The rock quarried throughout the state is a dolomitic limestone, occurring in perfectly horizontal beds varying in thickness from 3 in. to 5 and 6 ft. and lying within 6 in. to 2 ft. of the surface. Six plants were visited in Kentucky. All of the plants crush limestone of the same character as that found in Ohio. Five plants were visited in Tennessee. The rock crushed is a limestone of good quality when it can be obtained free from bands of shale or "rotten rock" as it is called locally.

Six plants were visited in Georgia, all located within a 50-mile zone of Atlanta. Three of these crushed granite as a by-product to the stone-block industry. Two crushed a bastard limestone and one a granite gneiss rock. All the plants visited have a small output and (with the exception of one of the plants crushing limestone), make crushed stone almost an incidental industry.

Seven crushing plants were visited in North Carolina, distributed north and south of an imaginary line extending from Asheville to Raleigh. All the plants crush granite rock, two making the crushing industry incidental to the stone block and monumental stone industry.

Procedure in Making Survey.—The most important element in the equipment of a crushing plant, in so far as quality of grading is concerned, is the screen. Screening methods therefore were given first consideration in the study of each plant. The data collected included the length over all, diameter, pitch, and speed of revolution of each screen, the number of screens in operation, and the length and diameter of each section of screen. If gravity or pulsating screens were used, their dimension, pitch, and size or holes in each compartment was obtained; the nominal diameter (or dimensions, if square holes) of each section of the screen at the time of inspection was recorded, together with the total length of each section having the same size holes. In addition, information was obtained pertaining to crushing and elevating machinery such as would present a complete flow sheet of operations.

The general condition and operation of the plant as a whole was noted and recorded. A record was made of each commercial size of crushed stone produced, including the name under which each size is sold, and the limits in size within which each grade is supposed to lie.

Finally, a sample of each commercial grade, available at the time of inspection, was obtained, and a mechanical analysis ot each sample was made on the spot. Samples of grades smaller than ¼ in. were mailed to Washington for mechanical analysis.

Screening Methods in Use.—All the plants visited are equipped with revolving screens, but a few in Ohio have in addition pulsating screens installed in various stages of the operation. Revolving screens, in the majority of cases, are used to obtain the larger sized products, while the smaller grades are obtained with the pulsating screens.

In its simplest form the pulsating screen consists of two or three rectangular frames constructed of wood and hung one beneath the other, each frame having a perforated metal or woven-wire screen attached to the under side. The three frames are in turn hung in frame work and rocked to and fro by means of eccentrics. If a three-tier screen is used the upper has the largest perforations and the lowest the finest. All grades discharge from the screen opposite to the feeding end. These screens may be set either in a horizontal position or may be inclined, combining, in the latter case, the principles of the gravity screen and pulsating screen.

General Results Obtained.—An analysis of the results of the mechanical analyses leads, in general, to the same conclusions as were noted in the 1917 survey. Thus, variations in pitch and speed of revolving screens, contrary to the general idea, appear to affect the grading very little. Likewise, it may be noted that, except in a very general way, the dimensions of the screens themselves have little influence on the sizes of the products. This, of course, does not mean that, in any individual case, the diameter, pitch, or speed of the screen does not influence the grading of the material produced. It does seem to indicate, however, that there are other influences at work which overshadow the effect of these variables.

The rate of feeding the stone into the screen, which, of course, varies continually during the screening operation and therefore can not be recorded, probably influences the grading to a marked degree.

Standard Requirements in Ohio.—In Ohio, practically all the operators are producing stone nominally in accordance with the state requirements for size. These requirements have been standard for some years, and, inasmuch as limestone is quarried throughout the state under practically the same conditions, it would seem that to produce these sizes revolving screens of the same diameter of perforations should be used in the various plants. As a matter of fact, this is far from true. For instance, of the 12 plants in the state producing the Ohio No. 1 standard size limestone (2½—3½ in. or 2½—4 in.), or its equivalent, by means of revolving screens, one plant has 2-in. holes in its screen retaining the product, two plants have 2¼-in. holes, six have 2½-in. holes, two have 2¾-in. holes and one has 3-in. holes. Likewise, in the case of the No. 2 Ohio standard size (2½—1½ in.), in the 11 plants producing this material the same relative variations in size of perforation may be noted. Thus in a state where standard sizes for broken stone used in rado construction have been in use for a number of years, revolving screens with 13 different sizes of holes are used to produce three grades of stone.

Screening Efficiency Greater.—For the purpose of making comparisons between the nominal and actual sizes of product, Table I was prepared.

It is interesting to note that the average efficiency of screening operations is somewhat greater among the plants visited in 1918 than among those in New England and the Middle Atlantic States. As recorded in the original report, 34 per cent of all the plants visited in 1917 produced the ordinary commercial sizes with less than 5 per cent variations from the nominal size of perforations in their retaining screens. Table I shows that 37 per cent of the plants visited in 1918 produced stone within this limit of variation. Again, whereas approximately one-half of all the plants inspected in 1917 showed less than 10 per cent variation from the nominal sizes, 62 per cent of the operations studied in 1918 were equally as efficient. This latter average is raised considerably by reason of the very efficient grading observed in the states of North Carolina and Georgia. The average results for the state of Ohio are practically the same as were obtained during 1917.

Specifications Purely Theoretical.—The reason for analyzing the data obtained in this manner is to secure figures based on actual screening operations, which might be used in framing practical specifications for stone sizes. The average specification covering the size of crushed stone products is purely theoretical. It usually requires stone graded between certain fixed limits without any allowance for imperfect screening. It is the custom, therefore, of most operators to use screens with openings slightly larger than those specified, so as to obtain approximately the sizes desired. This custom results in the production of more or less indefinitely graded products, which sometimes do, but much more frequently do not, meet the letter of the specification.

Uniformity in Nomenclature.—With the exception of the state of Ohio, there is practically no uniformity in the nomenclature used in designating crushed-stone products. The state of Ohio has, for some years, used a standard system of stone sizes, each size being designated by a number. The majority of the crushing plants in Ohio which were visited use the state system of numbers in designating their product. This is about as far, however, as the uniformity extends, because even the operators who use the same nomenclature

TABLE I.—EFFICIENCY OF PLANT SCREENING.

State.	Number of plants.	Approximate size of product	Proportion of plants showing the following variations from nominal size.			
			Less than 5 per cent.	Less than 10 per cent	Less than 15 per cent.	Over 15 per cent.
Ohio	15	4 to 2½ in.	34	68	74	26
	19	2½ to 1¼ in.	16	42	63	37
	16	1¼ to ¾ in.	31	50	63	37
	22	¾ to ¼ in.	50	68	73	27
	72	Average	33	57	68	32
Georgia	3	2 to 1¼ in.	67	100	100	..
	4	1¼ to ¾ in.	25	75	75	25
	6	¾ to ¼ in.	67	67	67	33
	13	Average	54	77	77	25
North Carolina	7	2½ to 1¼ in.	43	57	79	21
	7	1¼ to ¾ in.	43	71	100	0
	4	¾ to ¼ in.	25	100	100	0
	18	Average	39	72	92	8
	103	General av.	37	62	73	27

TABLE II.—ACTUAL SIZES OF PRODUCTS OF OHIO PLANTS.

Plant No.	Known as—	Mechanical analysis								
		Per cent over 3 in.	Per cent between							Per cent under ¼ in.
			3 and 2½ in.	2¾ and 2 in.	2 and 1½ in.	1½ and 1 in.	1 and ¾ in.	¾ and ½ in.	½ and ¼ in.	
5	..	40	28	32	..	..	..	..	..	..
9	..	52	36	12	..	..	..	..	..	..
10	..	18	82	..	..	..	..	..	..	..
11	..	73	23	4	..	..	..	..	..	..
12	1	34	30	30	6	..	..	..	..	..
13	..	36	40	24	..	..	..	..	..	..
18	..	..	12	5	..	..	..	..	..	..
20	..	..	..	9	..	..	..	..	..	..
21	..	..	..	..	..	..	..	..	..	..
23	..	..	..	..	..	..	..	..	..	..
5	..	..	..	38	56	6	..	..	..	..
9	..	..	6	91	3	..	..	..	..	..
10	..	..	12	47	40	1	..	..	..	..
12	..	..	..	47	33	19	1	..	..	..
13	2	..	11	60	29	..	..	..	..	..
18	..	..	..	36	47	12	5	..	..	..
20	..	..	5	34	37	21	..	..	..	..
21	..	..	36	47	12	5	..	..	..	..
23	..	..	..	..	60	40	..	..	..	..
5	..	..	..	..	30	61	9	..	..	..
9	..	..	..	..	46	53	1	..	..	..
10	..	..	..	..	17	52	27	4	..	..
12	3	..	..	..	12	52	27	9	..	..
13	..	..	..	..	1	49	32	18	..	..
20	..	..	..	..	2	80	16	2	..	..
21	..	..	..	..	2	83	15	..	..	..
9	..	..	..	..	..	16	20	31	26	4
10	..	..	..	..	..	..	5	28	63	4
11	..	..	..	..	..	..	11	82	7	..
12	4	..	..	..	..	..	..	36	40	21
13	..	..	..	..	..	..	10	47	43	..
18	..	..	..	..	..	54	18	21	7	..
20	..	..	..	..	..	..	33	60	7	..
21	..	..	..	..	..	42	27	18	13	..
29	..	..	..	..	..	..	6	67	15	12

do not always use the same screens for obtaining nominally the same product, nor do the products themselves have always the same grading. This latter point is brought out in Table II, in which the actual sizes of crushed-stone products sold by plants using the state nomenclature are compared.

That portion of the mechanical analysis included between the vertical lines in each subdivision gives the proportion of the total product which meets the state requirements for size. Some extremely wide variations from the state requirements are shown. The general tendency is to produce larger stone than that specified. This table shows that just 3 out of the 35 products indicated meet the state requirements for size as called for by the number under which each is sold.

One point in connection with the standardization of stone sizes which has not been discussed is the effect of character of stone on the maximum size allowable in various types of construction. It is recognized, for instance, that the sizes should be somewhat larger in the case of limestone than where granite or trap is used. It may be necessary, therefore, to modify the proposed system of sizes to cover this point.

American Shipyards Turn Out 422,000 Tons of Boats in June.—During the month of June American shipyards turned out 272 vessels, aggregating 422,889 gross tons, according to estimates of the Bureau of Navigation of the Department of Commerce. Of this amount of new shipping the Department's figures showed that 72 of the vessels were steel boats and totalled 329,981 gross tons; 39 wood, totalling 82,362 gross tons, and 161 vessels non-seagoing, totalling 10,546 gross tons.

The Coming of the Self-Propelled and Trackless Street Car

Under the above title Mr. W. J. [illegible] in "[illegible] Municipalities" makes some interesting observations on [illegible] has been done with the trackless street car and [illegible] expected from it in the future. The following is [illegible] from his article:

Some time ago in the city of Long Beach, Calif., a franchise was applied for and subsequently sold, [illegible] state law authorizing the recipient to run jitney busses over two streets of that city, the distance covered being about 2½ miles in each case. The successful bidder paid $[illegible] for the franchise, in addition to which he agreed to pay the city annually 3 per cent of the gross receipts. Upon the granting of the francise an ordinance was passed by the city prohibiting all other jitneys from operating on the streets which the franchise covered. The enterprise turned out to be a good business venture apparently, as the recipient has been operating the bus system continuously and [illegible] with profit ever since he procured it. Is the [illegible] a precursor of what may happen in other cities?

The jitney bus was popular from the outset. [illegible] it immediately brought in its train many annoying and perplexing problems for city officers to solve, while in the [illegible] the street railway companies grew more and more [illegible] daily as the jitneys cut into their business and continued to reduce their daily receipts. Many of the companies had paid big prices for their franchises, and the competition of the busses operated at a manifest injustice against them. In most cases the companies, as part consideration of their franchises, had been obliged to pave the street between their tracks and 2 ft. on either side, and they were therefore [illegible] in the anomalous position of having furnished a large portion of the smooth roadway which their competitors were now using against them, and without which they would be absolutely unable to operate at all.

Municipal ordinances were hastily prepared to meet the situation. Most of them demanded certain moral and physical qualifications of the driver, while nearly all required an indemnity bond to be furnished. Others prohibited the [illegible] from running on streets having street car lines. The requirement of an indemnity bond increased the cost of operation greatly, and resulted in many operators going out of business, while provisions which prohibited the operation of jitneys on streets having street-car lines put many others out of commission. In some cases the jitney drivers found it imposible to secure the required indemnity bond. For instance, in Washington the Supreme Court refused to grant an injunction to 200 jitney drivers of Seattle who sought to prevent the prosecuting attorney from enforcing the law, the court holding that if the jitney men could not obtain the kind of a bond defined by the statute they would not be entitled to the privilege of using the streets.

With trackless cars the routes may be [illegible] to suit public convenience or their termini [illegible] without additional expense. Not so, however, with the ordinary street car. It is confined to its tracks and cannot be diverted nor have its route extended until the tracks, [illegible] and wires have first been constructed and installed.

As to the economical phase of the question, it is only fair to say that the first cost of the [illegible] car or [illegible] in proportion to passenger capacity is somewhat more than the ordinary street car, but the greater cost is offset by the large investment required for a power [illegible]. On the other hand, the [illegible] poles and overhead wires, represent [illegible] capital that it entirely [illegible] in the case of [illegible]

The city of San Francisco recently [illegible] of auto busses [illegible] street car lines. These busses are [illegible] who drives the machine [illegible] gers paying as they [illegible] it is possible for others to [illegible] Electric light [illegible] the terminal points. Electric [illegible] are placed opposite each [illegible] confined to the outskirts of [illegible] handle only the most [illegible] result being that their [illegible] loss. The same situation obtains in Fresno with respect to the auto busses operated there as auxiliary extensions to the street car lines of that city. They, too, handle only the unprofitable part of the business, with a like result. Such cases, however, cannot be taken as a criterion.

At an address recently delivered in San Francisco, the City Engineer of that city stated that certain statistics kept by his office indicated that the busses operated by the city cost 15 ct. a mile, including depreciation, as compared with a cost of 25 ct. per mile for the municipal street cars. In response to a query, he voiced the opinion that the hilly condition of San Francisco would probably prevent the complete substitution of busses for street cars.

The officials of the company which is now operating auto busses under a franchise at Long Beach, Calif., claim they made an initial mistake in purchasing light cars and using pneumatic tires. Soon after commencing operaton they discovered their mistake and at once produced larger cars and had them fitted with solid rubber tires. All the former jitney bus operators in Long Beach were given an opportunity to invest their money in this new company so that to some extent it represents a consoliation of the former independent operators. The company is now perfecting its system, with results which some of the city officials claim are marvelous. Under the franchise the busses are required to run on schedule time. This has proved advantageous to the company as well as the public, and passengers can depend on such schedules. The company claims to be making money and paying dividends regularly to its stockholders.

Bond Premiums on Government Contracts

The form of "cost-plus" contract used by the construction division of the war department during the war provided in Article II under the heading of "Cost of Work" for reimbursement of the contractor's actual net expenditures. Among the various items was the following:

"(h) Such bonds, fire, public liability, employer's liability, workmen's compensation and other insurance as the contracting officer may approve or require."

Article IX provided that

"the contractor shall, prior to commencing said work, furnish a bond with sureties satisfactory to the contracting officer."

Notwithstanding these provisions, the comptroller of the treasury has recently held that the form of cost-plus contract in use by the construction division does not authorize the reimbursement to contractors of the cost of premiums on their bonds. This ruling has been adhered to in the face of strong objections by the chiefs of the construction division.

Upon inquiry of representatives of the construction division, it is ascertained that it is quite certain that all contractors having unsettled contracts for work under that division and money due them under such contracts will now have deducted from any balance due them the sum of all payments heretofore made to them covering reimbursement of premium on bonds. This will probably include not only their unsettled contracts but such payments made upon other contracts of this class upon which settlements have already been made. It is not possible to say whether those who have no current construction contracts will be called upon to refund all such sums heretofore reimbursed to them. This will depend upon the discretion of the disbursing officers of the war department and the orders of the accounting officers of the treasury.

This matter is one of wide importance to contractors and accordingly the officers of the Associated General Contractors of America have taken up the subject for conference with King & King, Attorneys, Washington, D. C. As a result of very careful consideration the Associated General Contractors have issued a Special Bulletin under date of July 2, from which we quote as follows:

If the amount of premium bonds already is deducted from moneys otherwise due upon current contracts, the contractors should accompany the voucher covering any such payment and showing such deduction with a letter containing substantially the following language:

"It is to be understood that in accepting payment evidenced by the attached voucher under our contract of ...., for constructing, ... we do so without in any wise waiving our legal rights to full reimbursement under the terms of our contract of all sums paid by us as premium on bonds. We expressly reserve our rights to reimbursement of all sums paid by us on such account."

This letter should be pasted to the voucher.

2. Those who are called upon to refund any payments of the kind noted should decline to do so absolutely and leave the Government to take such action as it may deem advisable looking to a recovery.

The attorneys named have given us their opinion that the contracts entitle the contractors to reinbursement of these premiums, that the deduction is unlawful, and that it can be recovered by future proceedings in the treasury department or before the court of claims.

The opinion of the comptroller above referred to was given as an advance opinion to several disbursing officers. This will govern the action of all disbursing officers for the future, but it is not conclusive even in the comptroller's office. The matter can be brought before the comptroller again upon a claim duly presented by any contractor. This claim must be filed with the auditor for the war department and will be disallowed by him and then appealed to the comptroller. The comptroller will then hear legal argument upon the merits of the question. The opinion already rendered will be considered by him as prima facie correct, but he will not hold it to be finally binding upon him, if convinced to the contrary by any arguments then presented to him. There are numerous precedents for the comptroller reversing in a claim thus brought before him, an advance opinion rendered to a disbursing officer.

Should the comptroller decide this test case favorably, the other claims will be paid. If the comptroller adheres to his unfavorable decision, a test case can then be taken before the court of claims. If the court of claims decides in favor of the contractor in the test case, the comptroller will probably reverse his decision and allow other claims of the same nature, if they have not already been brought before him and adversely decided.

It is also possible to test this question by insisting upon a suit being brought against a contractor by the United States. It may be thought best to take this course, but at present it is thought best to make the test by a suit in the court of claims.

It is not probable that any contractors will be pressed for payment of premiums already paid to them under settled contracts unless a decision should be rendered by the court of claims adverse to them. Such a result is not expected. If that is adverse, there will still be an opportunity for defense to such claims under the provision of Article IV of the contract providing that the monthly statement of coats and "all payments made thereon shall be final and binding upon both parties hereto."

This association expects to take up this matter as an association matter on behalf of the contractors interested. Nearly all of them are already members of the association and it is hoped that all others interested will join the association in order to hear their fair share of the movement. It is very important that contractors should leave the handling of this matter to the association, as independent action may interfere with the orderly handling of the test case in the manner above outlined.

All contractors, whether members of the A. G. C. or not, are asked to send to the Secretary, 111 W. Washington St., Chicago, Ill., copies of their correspondence on this subject, both letters received from the officers of the Government and their replies.

Texas Association of General Contractors.—An association comprising contractors engaged in general construction work in Texas has been organized and has opened offices in the First National Bank Bldg., Houston. The officers are: President, George F. Horton; vice-presidents; George Watson and Robert J. Potts; treasurer, Charles M. Davis; secretary, Jerome Cochran, Houston.

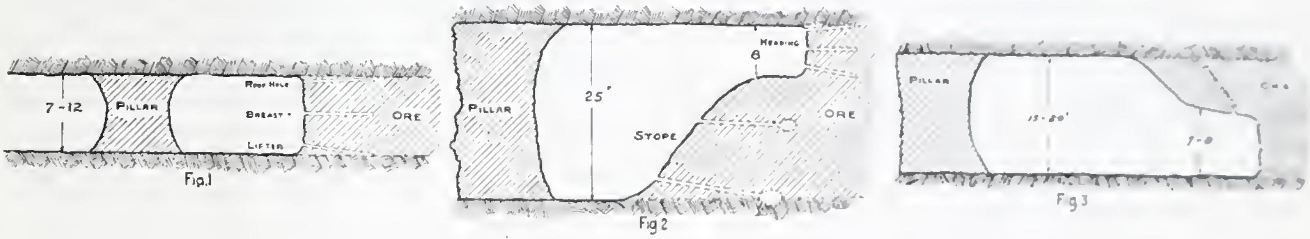
Blasting Practice in Joplin Zinc District

Blasting practice in the Joplin district is interesting because it is unique. It is unique because the ore bodies present unusual conditions, which affect drilling and blasting. A characteristic practice has been brought down from the days of hand drilling, which, to the mine operator coming from other mining districts, seems at first wasteful and inefficient, but, upon close application to the details, it will be found very well adapted to the conditions met in mining the cherty, water-course ores of the Joplin district. An interesting description of the blasting methods in this district is given by Mr. R. H. Summer in the July Du Pont Magazine, from which the matter following is taken:

The Joplin district takes in a territory adjacent to Joplin, including the Webb City sheet ground deposits and the mines of Ottawa County, Oklahoma and Southeastern Kansas.

In describing the blasting practice of this district, the mines may be divided into two classes, namely, the "sheet ground," which embraces most of the Joplin-Webb City section, and the irregular deposits or "runs" which apply to most of the Oklahoma-Kansas mines.

The ore deposits of the "sheet ground" lie in horizontal sheets of a generally uniform thickness and extend over large areas. The mineral content is more or less uniform, the zinc and lead sulfids occurring imbedded between the layers of chert and in crevices or small openings.



Drilling Methods in Joplin Zinc District.

The "runs" or irregular deposits, which are characteristic of the Oklahoma-Kansas mines, are richer in mineral content and vary to a great degree in all dimensions. These elongated deposits usually follow old underground water courses where often huge crystals of zinc sulfid, lead sulfid and calcium carbonate have been deposited on the walls of openings, forming rich caves, varying in size from small pockets to those of a hundred feet or more in length. The gangue or non-valuable material in the "runs" is chiefly flint and limestone, sometimes in layers resembling "sheet ground," but more often in a conglomerated bouldery and brecciated mass with the mineral values filling in the interstices. The vertical extent of irregular ore bodies is higher than the sheet ground, varying up to 70 ft. "Sheet ground" varies from 6 to 20 ft. in thickness.

Shafts, usually 5 by 7 ft., are sunk a depth of from 175 to 300 ft. to the bottom of the ore body. Electric blasting is now used almost entirely for shaft work. The center cut system is used, usually with four cut holes, four relief holes and four corner or squaring up holes. Instantaneous electric detonators are used in the cut holes; first delay electric igniters in the relief holes and second delays in the corner holes.

Gelatin dynamite of 35 per cent and 40 per cent strength is used in charging the holes. When charging is complete, the shots are all connected in series and fired by blasting machine after all men are well away from the shaft.

Drifts are run out from the shaft into the ore body in all directions, except, of course, in the narrow "run" deposits where the drifts follow the ore. Pillars from 20 to 40 ft. in diameter are left to support the roof, spaced according to the height of the ore body and the condition of the overlying material.

Air-hammer drills with water attachment are used almost exclusively, although there are some piston drills. The starting bit is from 2½ to 3 in., gauged every 2 ft. down to from 1¼ to 1½ in. The hard, brittle flint wears steel exceedingly fast. This fact along with the open ground, drilling into crevices and changing ground makes drilling difficult and opening, and, again the lower hole must be placed at a disadvantage because of a known crevice or pocket. The character of the material blasted is responsible for the practice of chambering, locally known as "[illegible]," the bore holes so that a greater quantity of explosives can be charged and hence more tonnage realized per foot of drilling. Experience has demonstrated that the increased quantity of explosives used is often more than compensated for by the saving in drill steel and labor costs.

Breaking the ore in the headings may be divided into three classes:

Drilling and Blasting in Low Ore Faces. Where the ore face is low (see Fig. 1), from 7 to 12 ft., the round of holes is drilled so as to blast out the entire face at one setting. From four to eight holes, 8 to 12 ft. deep, are drilled per round. This class applies chiefly to sheet ground deposits.

Five holes is an average round with two breast holes, two roof holes and one lifter, locally called a "stope" hole. This is somewhat confusing as there is no differentiation in nomenclature of the real "stope" hole and the bottom hole in the heading or cutting in round. A round of holes of this kind is drilled ordinarily a little deeper than the height of the heading being driven and are burdened so that the round will break almost as much across the toe as the depth of the hole. The holes are chambered and blown out by the drill man and, later, charged and fired by the powder man.

Drilling and Blasting In High Ore Faces. In higher faces affects the blasting practice to a great degree. Often a well-balanced round is spoiled by drilling into an unforeseen of ore (see Fig. 2), from 12 to 70 ft., the heading is driven at the top of the ore body with machine mounted on 6 to 8 ft. posts. The material left on the bench below is taken up by underhand stoping in one or more benches, depending on the vertical extent of the ore. The heading is carried ahead of the stope just far enough to permit the machine men to work. In this way the blasted material from the heading rolls down the stope by gravity and obviates shoveling in the heading. From five to eight holes, 6 to 10 ft. deep, are drilled per round in the heading.

After drilling is completed, the machine man chambers when his judgment or that of the powder man indicates, with from 1 to 2½ lb. of explosives. Each hole is then blown out with a blower attached to the compressed air hose, leaving the holes clean and free from the cushioning effect of dust or rock particles. In some mines where the material is easier breaking, chambering is found unnecessary in the heading holes.

The horizontal holes (stope holes) driven in the bench below are 12 to 14 ft. deep and carry a burden from 10 to 12 ft. A stope hole of this kind fairly squared up on the collar will break from 150 to 200 tons.

Stope holes are chambered once, twice or more times as the burden on the hole and hardness of material may demand. The best judgment of the mine foreman, powder man and machine man must be used in chambering stope holes, particularly in the irregular deposits of Oklahoma, for one hole may be bottomed in a solid chert or dolomite boulder, while the next may be in a soft ore pocket or even in a cave. The size of the pocket governs the quantity of explosives charged, and it is difficult to secure approximately just the right size chamber. Because of this variable condition, a hole will sometimes be lost, due to underloading, and, again, a hole will be charged with a much greater quantity than is actually needed. It also happens in open crevicey ground that an opening near the toe of the hole will cause the explosive force of the gases generated by detonation to be uselessly dissipated.

Modified Overhead Stoping Method.—When the ore face is in material of sufficient hardness so that the overhanging rock will not slab or fall down (see Fig. 3), a modified overhead stoping is economically used. It is almost the reverse of the method just described; the heading being advanced at the bottom of the ore body on a 6 to 8 ft. machine post. When the heading is advanced from 15 to 25 ft. ahead of the overhanging material, holes called "glory holes" are drilled 10 to 12 ft. deep pointing backward and upward 45° from the face. This is an ideal practice when conditions permit for an ore face from 15 to 20 ft. high. The heading holes and "glory holes" are chambered and prepared for charging as described above.

Kind and Strength of Explosives Used in Joplin District.—About every kind and strength of dynamite made has been used from 17 per cent "straight" nitroglycerin up to 80 per cent gelatin dynamite. The tendency the last two years has been toward the use of lower grade dynamites with a stronger detonator. The results produced indicate this to be good practice provided the grade is not too low, causing the miners to do more chambering. The "extra" grade dynamites of 30 per cent and 33 per cent have proved very efficient when used with a No. 8 detonator. They are of just about the right quickness for the material blasted, and the heaving effect produced is especially desirable in stope work.

In wet or close work, when ventilation is poor, in shaft sinking, raises or drifts, gelatin dynamites are used. In open stope work, 30 per cent and 35 per cent gelatin will usually meet all requirements. Shaft sinking, raising or drifting usually require 35 per cent or 40 per cent gelatin.

Since the introduction of lower grade "extra" and gelatin dynamites, fatal accidents have been materially reduced, due to these explosives being more insensitive to shock than the straight dynamites. There still exists, however, in some mines, the bad practices of "short fusing" on the chambering shots, and chambering on shift. These practices go hand in hand as the object of "short fusing" is to shorten the time wasted by all men within range of the shot. When chambering is done at the end of shift, longer fuse is used and the men are not exposed to mine air contaminated by fumes from explosives.

Method of Loading Bore Holes.—The charging of the bore holes is usually done by a powder crew after the drilling, chambering and blowing-out of holes is completed by the drill man. The dynamite cartridges are slit and stuck on a capper spike inserted into the end of the wooden tamping bar, held on by a copper ferrule, which also serves to keep the bar from being quickly worn by the sharp projecting points of chert. The deep jagged bore holes necessitate this method of lodging the dynamite in the back end.

The primer cartridge is usually placed near the top of the charge with two or three cartridges tamped on top. Fuse is cut in 8 or 10 ft. lengths and trimmed at least 6 in. to effect the proper rotation of shots. Tamping material or stemming is rarely used, and there are some logical reasons for this fact. First, there is an absence of a good tamping material, the best available is to fill tamping bags with fine tailings from the concentration tables. If these are absolutely dry they make very poor tamping, and, if damp, the bag breaks and is pushed into the rough bore hole with attendant difficulties. Secondly, in the general practice there are always some holes nearby that are as heavily burdened near the collar as on the toe. If the material is soft or crevicy at the toe and the hole is tamped or stemmed there is a good chance of shooting out the back end and leaving the front part of the hole "hanging in the wall."

In tight work, however, as in drifts, shafts, or raises, there is unquestionably a fair portion of the effect of the explosive gases lost by the failure to confine them with suitable material.

The primer cartridge is almost always made by lacing the fuse transversely through the cartridge and inserting the cap diagonally into the side. A safer and more efficient manner is to tie the fuse to the cartridge with a piece of string and eliminate the liability of igniting the charge from a spit size of the fuse.

Cost of Blasting.—Explosive costs per ton of material broken vary considerably throughout the district, and also vary from month to month in the same mine, particularly in the Oklahoma section where the mining conditions vary so greatly, due to changing conditions of the ground. The cost of caps and fuse is included in the explosives cost.

At the present market price of dynamite, the costs range from 13 to 30 ct. per ton, with the average approximating around 18 to 20 ct. A better way to state explosive costs is in terms of pounds of dynamite per ton of rock broken, and add a cent per ton to cover caps and fuse.

Some mines are averaging 0.75 lb. of explosives per ton, which is about the lower limit. The high limit is approximately 1.75 lb. with a few occasionlly exceeding that amount.

In most cases where the practice is good and the proper explosive particularly adapted for the conditions met is used, an explosive consumption of from ¾ to 1⅛ lb. can be obtained and is within the law of good practice. More than this amount, while sometimes unavoidable, is usually bad practice and is due to improper storage or use of explosives, or due to using an explosive not adapted to that particular work.

Rules for Construction Superintendents and Foremen

The Construction Section of the National Safety Council, Chicago, has issued recently the following "safety first" rules for superintendents and foremen:

First Convince Yourself that accident prevention is worth while. It reduces accidents 75 per cent or more, it reduces labor turnover, and increases efficiency. Others have obtained these results on jobs both large and small; resolve that you will obtain them on your work.

Get the Men to Think and Act Safety. Instruct all new men in safety when they are hired. Appoint safety committees and safety men. Install safety signs, warning signs, and safety bulletin boards. Invite the men to suggest safety rules and cautions. Stimulate the instinct of self-preservation.

Use Safe Methods in Doing the Work. See that all safeguards are used, that materials are safely moved and well piled. Do not overload equipment, floors, falsework or scaffolds. Keep passageways open and the entire job clear of rubbish. Do not let bolts, nuts or small tools lie around to be knocked off or tripped over, nor boards with projecting nails to be stepped on. Permit no one to stand or work under a load or to ride a load being hoisted, and do not hoist a heavy load with a horizontal boom. Prohibit horseplay and practical jokes and see that they are eliminated. The public should be excluded from the job. Do not let any one take a chance.

Use Good Tools and Equipment. Inspect frequently and keep them in good condition. Guard all gears, pulleys, belts, electrical apparatus, etc. Provide goggles when needed to prevent eye injuries. Remember that the goose neck and gudgeon pin are the critical points of a derrick. Discard all poor equipment at once. The strength of guys, hoisting lines, ropes, blocks, hooks, chains and slings and their fastenings should be beyond question. Keep tools sharp and handles and striking faces in good condition.

Use Good Timber, Well Framed and Sway Braced for false work, scaffolds, shores and temporary supports. Prevent falls and injuries from falling objects by providing hand rails, toe boards and wire screens around elevated structures, scaffolds, openings and pits. Keep ladders and runways in good condition.

Do Not Work if Conditions Are Unfavorable because of high wind, poor light, storm, heat or cold, etc.

Fit the Man to His Job. Do not let a reckless, drunken or sick man work for you.

Be Vigilant. Instruct your men to be watchful for the safety of themselves and fellow-workmen.

Be Prepared for Accidents. Secure a first aid kit and learn why and how to use it. When starting a job find out about doctors, hospitals and ambulances and post the information near the telephone. Learn the prone pressure method of resuscitation from drowning, asphyxiation and electric shock. Treat all small cuts and scratches to prevent infection.

Ask Your Home Office or the National Safety Council for assistance if you need it. They will gladly give suggestions that will assist you to solve your safety problems.

MANAGEMENT AND OFFICE SYSTEM

This section is published twice a month: (1) In the Waterworks and Hydraulic Monthly issue, and (2) in the Railway and Excavation Monthly issue. It covers what may be broadly termed "management engineering" as applied in the civil engineering and construction fields.

Expediting the Engineering Work of the Construction Division of the Army

By A. B. McDANIEL,

Principal Engineer, Construction Division of the Army.

After accomplishing the feat of building 32 training camps in 90 days for our rapidly developing army during the fall of 1917, the construction division of the army was confronted with the task of supplementing this initial construction with a great variety of projects for the use of the various branches of the service. These projects included terminals, army supply bases, quartermaster interior depots, docks, piers, aviation fields, plants for the manufacture of ordnance, munitions, acids, etc., housing for manufacturing plants, etc. This work comprised 535 operations at 442 different and widely separated locations, employing 200,000 men at one time in the field and expending (exclusive of maintenance and repair work) well over $1,000,000,000.

Early in the fall of 1917 it became evident that some provision would have to be made for the establishment of an engineering organization for the standardization of the drawings, specifications, schedules, and estimates prepared in the office of the division, or received from outside sources; for the co-ordination of the work of the engineering and building branches of the division, and the expeditious handling of the engineering work through the office.

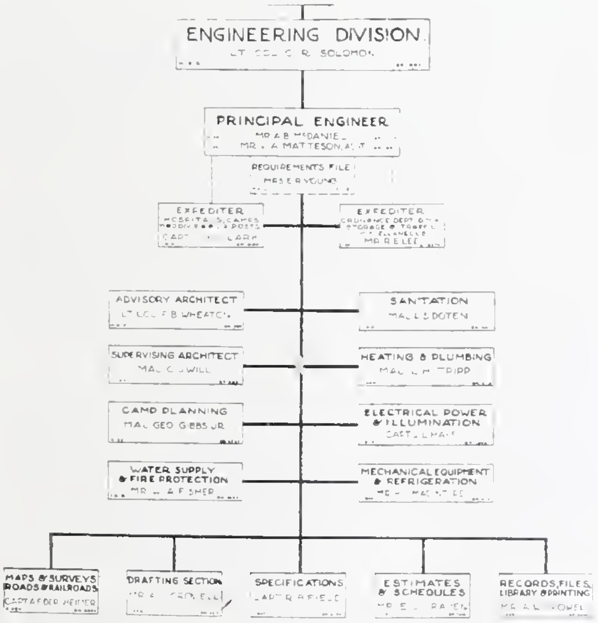


Fig. 1—Organization Chart of Engineering Division.

The engineering branch, under the direction of Colonel F. M. Gunby, had early established various sections for the preparation of general building plans, the designs and estimates for various utilities, the preparation of schedules and materials, and the other phases of engineering work preparatory to actual construction by the building branch. With the tremendous expansion of the work for the army, the need of the co-ordination of the various activities of these various sections became increasingly important and resulted in the establishment of an expediting office under the direction of Major H. J. Burt. The chief function of the expediting office was the correlation of the work of the various offices of the advisory engineers, advisory architect, scheduling section, estimating section and drafting sections, and served as the point of contact with the building branch. This general scheme has been developed gradually and systematically during the past 16 months and has resulted in securing a close co-operation of the various departments of the engineering division, a definite systematization of the plans, specifications, schedules of material, and estimates, and especially in bringing about the more expeditious handling of the work.

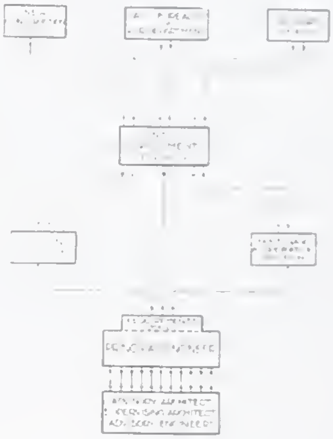


Fig. 2—Method of Routing Work.
Broken line indicates technical mail.
Solid line indicates non-technical mail.

Duties and Functions of the Organization.—Figure "1" shows the general character of the organization as it has been finally developed during the last few months. In order to understand the organization and functions of the engineering division, its duties should be primarily understood. It receives from the various bureaus of the war department a statement of their construction requirements in this country, establishes fundamental engineering policy for all construction work, and provides the necessary surveys, drawings, schedules, estimates, technical details and such other engineering data as may be required. It has a number of other functions, such as the preparation of estimates and furnishing data upon which to base requests for appropriations or authority for construction work, etc.

The executive office of the engineering division is under the direction of the principal engineer, who co-ordinates and expedites all the engineering work for projects handled by the construction division. All the sections of the division function through this office. It furnishes information to the other divisions with reference to engineering work, drawings, specifications, and estimates. The principal engineer reports to the officer in charge of the division, who is the administrative head of the engineering division and the liaison with other divisions and with the chief of the construction division.

The advisory engineers prepare fundamental plans and specifications for the utilities at the various projects. They prepare such estimates, reports, recommendations, and schedules of material as are required, and are responsible for the securing of the necessary field and office data for these purposes. As will be seen, from an inspection of the organization chart, Fig. 1, there are at present 13 different sections, each of which has its peculiar duties, but all are working in close co-operation and function through the office of the principal engineer. The title of each office gives a general idea of the character and scope of the work which it performs, but a more definite understanding may be secured from the following statement:

The advisory architect is consulted on matters of military building requirements, correct size, character, design and location of building, and sundry construction details.

The supervising architect acts as the medium by which requirements, furnished through the office of the principal engineer, are developed into working drawings. He is responsible for architectural design.

The advisory engineer on surveys, maps, roads and railroads makes the necessary surveys, topographical and other maps and provides for the designs and layouts of roads and pavements, railroad tracks, turnouts, yards, trestles, and coal storage facilities; he investigates and reports as to the advisability and economy of installing industrial railroads for the transportation of camp supplies.

The advisory engineer on camp planning compiles and lists the building requirements for camps, cantonments and posts, and prepares the general layout and maps.

The drafting section prepares all plans, and maps, working drawings, layouts, schedules and details, under the direction of the architects and advisory engineers.

The specification office has charge of the preparation of all specifications written in the division, and of the revision and approval of the specifications received from outside sources.

The advisory engineer on water supply and fire protection provides the necessary engineering information for water supply and distribution for all purposes including fire protection. He also has charge of all other fire prevention measures.

The advisory engineer on sewerage and sanitation has charge of the engineering work relating to sewerage systems, sewage pumping stations, sewage treatment plants, surface and sub-soil drainage systems, transfer stations for waste, garbage disposal, incinerator plants, etc.

The advisory engineer on heating and plumbing has charge of the engineering work in connection with heating, ventilation, plumbing work and also the design and specifications for bakery and kitchen equipment.

The advisory engineer on electrical work and illumination performs the engineering work in connection with lighting, power installation for all projects, the selection of special electrical equipment, communications with central station companies, and inspection of electrical systems.

The advisory engineer on mechanical equipment and refrigeration has charge of the selection and design of machinery and mechanical equipment for various projects and the designing of coal handling machinery, icemaking plants, cold storage and other facilities.

The section on estimates and schedules prepares the preliminary estimates of cost and schedules of material which are necessary for the securing of authority for new construction, or repairs on existing work and for the letting of contracts.

The expediters are a part of the office of the principal engineer and the points of contact between the engineering division and the building division, receiving requests, information and data from the field through the building division or other agencies, and after the necessary steps, deliver plans, specifications, schedules, estimates and bills of material to the constructing branch, in every case functioning through the office of the principal engineer.

Method of Operation.—The method of routing work through the engineering division and its relation to outside agencies is clearly shown by the accompanying chart, Fig. 2. It should be noted that requests may emanate from three sources: from other bureaus of the war department; from the constructing quartermaster with relation to new construction in the field and from the utilities officer with relation to repairs and maintenance of existing work in the field. All requests coming to the office of the construction division of the army are sent directly to the central requirements division where they are reviewed, recorded, and then sent directly to the division concerned. Requests for new construction would come from the requirements division to the building division and thence to the engineering division. Requests for work in connection with existing construction would be routed to the engineering division through the maintenance and operation division. Usually requests of a general character received from other bureaus of the war department would be routed directly to the enginering division.

All mail forwarded to the engineering division is received in a mail and file room, where it is stamped with the time and date of arrival, and a record made of any cases requiring special action. From the mail room, all correspondence goes to the office of the principal engineer, where the assistant principal engineer reviews each case, makes a suitable record of the same and forwards it to the officer concerned. Matters relating to new construction are sent to the expediter who has the work in charge, while correspondence relating to specific matters are routed to the advisory architect or advisory engineer for consideration, recommendation, or action.

The expediting engineer, upon receipt of the request, proceeds to gather together all available information concerning the case and this often requires the securing of further data from the field or other bureaus of the war department. It then becomes the principal duty of the expediting engineer and his assistants to correlate the preparation of the plans, so that all parts of the work will proceed with all due expedition. Suitable information is furnished by them to the advisory engineers, camp planning department, general drafting room, survey office, and such other agencies as are concerned in the co-operative effort to secure the proper preparation of the plans and specifications.

As soon as the information is available in the office of the advisory engineers, it is assembled by the expediting engineer to form a complete case, consisting of plans, specifications, list of buildings, estimate and supporting papers. Each advisory engineer is held responsible for the preparation of the layout plans, schedule of materials and estimate for his particular utility; water supply, sewerage, roads and railroads, fire prevention, mechanical equipment, refrigeration, heating and plumbing, or electric power and illumination.

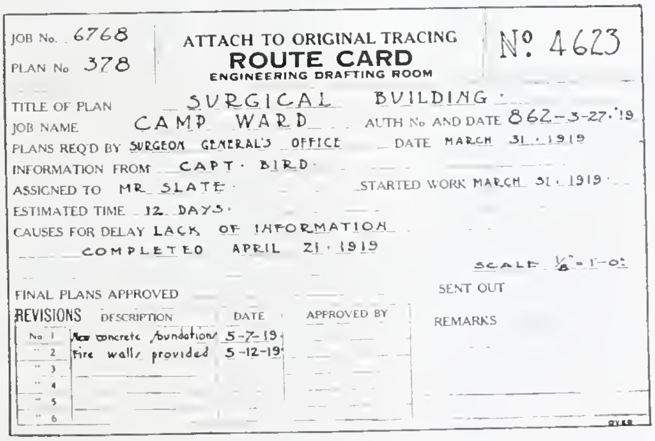
When the case has been prepared for outside parties, it is forwarded to the office concerned. When an estimate is necessary, a request is prepared on the standard form, which serves to combine the information for a request to the estimating section for an estimate and the necessary data and request to the director of operations for the approval of the project and the authorization for the allotment of funds for the use of the building division in connection therewith. This formal request is accompanied by a schedule form which gives a list of the various types of construction, buildings, etc., and other utilities, distributed under the several accounts: B and G, Buildings and Grounds; W S, Water Supply; R S, Regular Supplies; C and R of H, Construction and Repair of Hospitals; R W W D, Roads, Walks, Walls and Docks; M P E, Military Post Exchange, etc. This division of funds is for the use of the requirements division, which has charge of the distribution and allotment of funds.

An interesting feature of the work in the past during the emergency period before the signing of the armistice was the issuance to the various departments of the construction division of an advance information sheet, familiarly known as the "pink sheet." This sheet was issued as soon as any information on a particular case was available, and served as a memorandum as to the character and the scope of the work contemplated. Originally this sheet was a more or less confidential circular containing the earliest available, but often meager, information. Later it contained an approximate estimate of the amount of principal materials and other information which would be needed by the procurement division, war industries board and other governmental agencies.

An interesting feature connected with the "pink sheet" was the advance preparation of drawings, bills of materials and estimates on projects which were of a tentative nature, and on which the authorization from the secretary of war had as yet not been secured. In most cases it enabled the preparatory work to be completed and much of the finished work, drawings, etc. In a few instances complete preparations were made, materials ordered subject to cancellation and field forces organized, so that when the authorization was finally received actual construction work was started on the job within 24 hours of the receipt of the first authoritative news that the work was to be done. In a few instances of course this resulted in wasted effort when the prospective job failed to materialize; but these cases were so few that the system was fully warranted by the results obtained.

The general office of the principal engineer has instituted and maintained a system of records and files which furnishes a definite and accurate record of all authorizations, all requests for schedules and a record of the date of completion of every drawing and revision or addition to drawings, including utilities. A chart record showing the progress of the preparation of the drawings and schedules has been kept for reference use.

Functions and Operations of Drafting Section.—The functions of the drafting section comprise the preparation of designs, working drawings, plans and sketches for the construction and repair work coming under the jurisdiction of the construction division. The preparation of drawings, etc., is started by means of a standard form which is filled out by the expediting engineer handling the work. This request, addressed to the chief draftsman, gives the subject, authorization or project number, location and description of the work and is accompanied by such available information as will assist in the execution of the work. The request is presented by the chief draftsman to the "squad leader" who is to be entrusted with the preparation ot the designs and drawings of that particular project. The squad leader assigns various phases of the work to his assistants, and the drafting work from then on is conducted under the general supervision of the supervising architect for building drawings and advisory engineers for the layouts of utilities. The advisory engineers review the preparation of the drawings and furnish such additional information as comes to hand in their respective branches of the work.


JOB No. 6768
PLAN No 378

ATTACH TO ORIGINAL TRACING
ROUTE CARD
ENGINEERING DRAFTING ROOM

Nº 4623

TITLE OF PLAN SURGICAL BUILDING
JOB NAME CAMP WARD AUTH No AND DATE 862-3-27-'19
PLANS REQ'D BY SURGEON GENERAL'S OFFICE DATE MARCH 31 · 1919
INFORMATION FROM CAPT · BIRD ·
ASSIGNED TO MR SLATE · STARTED WORK MARCH 31 · 1919 ·
ESTIMATED TIME 12 DAYS ·
CAUSES FOR DELAY LACK OF INFORMATION
COMPLETED APRIL 21 · 1919
SCALE ⅛" = 1'-0"
FINAL PLANS APPROVED
SENT OUT

REVISIONS	DESCRIPTION	DATE	APPROVED BY
No 1	New concrete foundations	5-7-19	
" 2	Fire walls provided	5-12-19	
" 3			
" 4			
" 5			
" 6			

REMARKS

OVER

Fig. 3—Front of Typical Route Card.

Names of draftsmen working on the drawing and dates of their work are entered on back of card. Space also is allowed for "Remarks, etc." Actual size of card, 4 in. x 6 in.

At the initiation of a project the squad leader decides upon the number of drawings necessary to complete the design and procures from the chief file clerk an assignment of drawing numbers and "route cards." The function of a route card is to furnish a record of the drawing from its inception, and thus it is attached to and remains with the drawings up to the time of final approval. On this route card is noted all the information necessary to record the progress of the preparation of the drawing. The cards are numbered consecutively for ease of identification in the files. The route card numbers are noted on the corresponding drawings. An estimate of the time for the completion of the drawing is made when the route card is issued, co-operatively by the route card clerk and squad chief. Causes of delay in the completion of the design are noted, if necessary, on the card, and a copy of the route card is kept in the office of the chief draftsman so that the latter can be acquainted with the progress of the work at all times and the history of the drawings ascertained at any time. The route cards have proved to be of invaluable assistance in maintaining efficiency of operation of the drafting office. Every morning the route card clerk makes a personal visit to each draftsman and compares his card record with the actual status of the work. In this way, any lagging or unnecessary delays are noted and steps taken at once to expedite the work. Figure 3 shows a typical route card.

On completion of the drawing the squad chief checks and signs it if correct. The drawing is then handed to the supervising architect or advisory engineer concerned, who inspects it and accepts it with his signature if the plan fulfills the requirements of the design. The drawing with the route card attached is then sent to the office of the principal engineer, who reviews it and approves. Upon approval, the drawing is immediately recorded by the chief clerk of the expediting office and then forwarded to the blue-printer with orders as to the number of prints required and instructions as to forwarding. From here the tracing is sent to the office of the chief file clerk, who makes the proper records and places the drawing in the permanent file, where it is available for further printing and revisions, when necessary.

The revision of a drawing follows practically the same procedure as noted above for the preparation of the new design. The route card is obtained from the card file and accompanies the drawing until approved by the principal engineer. Upon the approval of the revised drawing the route card is signed and returned to the file for record.

All drawings are numbered in accordance with the decimal system used by the war department in the filing of its correspondence. Thus organization charts receive the number 320.2, preceded by the letters J. O. (job order). The various plans are numbered consecutively, starting with number 1. In addition to the general assignment of job order numbers for standard drawings, each project is assigned a number and all drawings pertaining to that job are given the job order number followed by a drawing number. These job order numbers start with 6,100 and run consecutively up to 6,500, allowing for 400 main projects.

Two classes of drawings are kept on permanent file in the file room of the drafting section: linen tracings and blue prints. The former are generally prepared in the drafting office of the division, and the latter are sent in from drawings made at the job. All drawings referring to one project are kept in a separate folder, which is filed in proper numerical order, in a steel vertical filing case. Four standard sizes of drawings are used: 8 x 10½ in., 11 x 20 in., 18 x 24 in. and 24 x 36 in. Larger drawings are made of maps and large general projects.

The record of drawings is made first in the loose leaf book in which an alphabetical index of projects and drawings is kept up to date. Later these records are transferred to a card index which contains a white card for each tracing and a blue card for each blue print. This index is arranged numerically in accordance with the various projects.

When a drawing is received by the file clerk the chief draftsman and the supervising constructing officer interested are notified that the plan is being placed on file and prints can be secured upon application. One print on cloth is prepared for the reference file and one print on paper is sent to the supervising constructing officer for his file. On written request by the supervising constructing officer, blueprints are prepared and sent direct to the officer in charge of construction in the field, who is usually known as the "constructing quartermaster."

By the system berein outlined in a general way, means have been developed for the systematic handling of the machinery for engineering services of a large organization, which works with considerable precision, a minimum of confusion and lost motion and a consequent saving of time. A considerable organization has been necessary to insure the proper functioning of the system, but it has been found fully warranted by the speed with which the work has been accomplished and the great economy as to the cost of engineering services. This last item has been very much less than is experienced in private engineering practice.

New Engineering Societies.—The South Carolina Association of Civil Engineers was organized July 8 at Columbia, S. C., with about 75 members. J. E. Sirrine, Greenville, S .C., is president; G. E. Shand, Columba, first vice-president; W. L. Lee, Sumter, second vice-president, and John McCrady, of Charleston, S. C., secretary and treasurer. The Western North Carolina Engineers' Association was organized July 7 at Asheville, N. C. The temporary officers include C. H. Neal, chairman and acting president; D. M. Williams, secretary, and T. M. Howerton, assistant secretary. A committee was appointed to draw up a constitution and this probably will be adopted at a meeting to be held July 19.

Labor Efficiency in Railroad Maintenance

Mr. F. S. Schwinn, Engineer for Receiver, International & Great Northern Ry., in the Railway Review, makes an analysis of some statistics on railroad labor, and draws some interesting conclusions, the most startling of which is that, owing to various causes, the "inefficiency" of the present day labor in the maintenance departments is causing an annual loss to the railroads of $108,000,000. His method of arriving at this conclusion is abstracted below:

Records of railroad maintenance, during the 5 or 10 years preceding 1918, have indicated that the expenditures for labor bore a fixed or constant ratio to the total maintenance expenditures, regardless of increased costs of both labor and material. In other words, the number of hours or days of labor required to use or apply a certain amount of material remained the same. This condition was probably due to the fact that, after years of practice, maintenance officials had evolved definite annual plans for the upkeep of the property which were based upon the most economical and efficient methods peculiarly adapted to the circumstances surrounding the property in their charge. Efficiency was compulsory in order to meet the ever increasing and burdensome limitations upon railroad operation resulting from the numerous laws and regulations of the various legislative and controlling bodies.

But, with the advent of Government control of railroads, there was presented an opportunity to secure rights without the complete fulfillment of duties. The natural tendency was to gravitate toward the path of least resistance. The result was an enormous increase in compensation with a surprisingly large decrease in the individual efforts put forth. Advantage was taken of the Government's desire to improve conditions, and wages, so as to more nearly conform to the advanced cost of living; there was an attending slackening of efforts in all departments, and especially in the maintenance department where the standards of efficiency had been so high before Jan. 1, 1918.

The operating statistics section of the division of operation, United States Railroad Administration, recently made public a statement giving the number of railroad employes and their compensation for the month of January, 1919, as compared with the month of December, 1917. An examination of this statement will give some very interesting facts concerning the efficiency of labor under Government control. It shows that, although material was and still is comparatively hard to obtain in anything like sufficient quantities for adequate and proper maintenance, the amount of labor employed was not correspondingly reduced, but was actually increased. It would be absurd to suppose that any considerable part of this labor could be employed to advantage without the necessary material, as maintenance required the combined use of labor and material. Then the conclusion must be that the efficiency of labor has suffered.

We find an increase of 8.6 per cent in the days and hours worked by employes in the maintenance of way and structures department in January, 1918. There was practically no change in the operated mileage which could cause this increase. Neither was it caused by variation in the amount of traffic handled, nor by the amount of material used, as both of these items show a considerable decrease as compared with December, 1917. Then this 8.6 per cent can only represent inefficiency of labor.

In the maintenance of equipment department, we note that there is an increase of 8.2 per cent in days and hours worked. The amount of repairs made per locomotive and per car, coupled with the lack of available material, was less; and the traffic, necessitating the repairs to equipment through wear and tear, had fallen off over 10 per cent. But these facts appeared to have no effect upon the amount of mechanical department labor required. Why? We are confronted with inefficiency as the only logical answer to the question.

Checking Percentages by a Chart

The principle that statistics must be reduced to significant percentages in order to attain their maximum value is generously illustrated in the summaries of the operating statistics section of the railroad administration. Such a large use of percentages, of course, means a great deal of office routine in the preparation of the summaries. As far as the operating statistics section is concerned, however, much of this routine is limited to checking. Only percentages in the totals for districts and regions actually have to be computed, as figures for the individual roads are already computed on the O. S. forms. Not only percentages, but all figures derived from basic data must be checked before they are entered on the summaries, and this constitutes a large part of the work of preparation.

A chart that has proved very useful in this work is described by Mr. William Wyer, Statistician, U. S. Railroad Administration, Operating Statistics Section, in a recent issue of the Railway Age, to which we are indebted for the matter in this article. The chart is not only an absolute check on percentages computed in a certain way, but is also an indirect check on all figures affecting the percentages in question. The chart applies to the following general case:

Suppose that one basic figure is divided by another basic figure to obtain an average. Suppose, further than both basic figures are given for two consecutive months or years. The average will then be computed for these two periods, and there will, of course, be percentages of increase or decrease applying to both of the basic figures and to the average. The set of related figures numbers nine, as shown in the following illustration:

A. B. X RAILROAD.

Item.	December, 1918.	December, 1917.	Per cent change.
1 Net ton miles	124,337,000	108,808,000	14.3
2. Train miles	307,000	278,000	10.4
3. Net ton miles per train mile (1 ÷ 2)	405	392	3.3

Referring to the chart, and following the instructions thereon, its application as a check on the above figures may be readily seen.

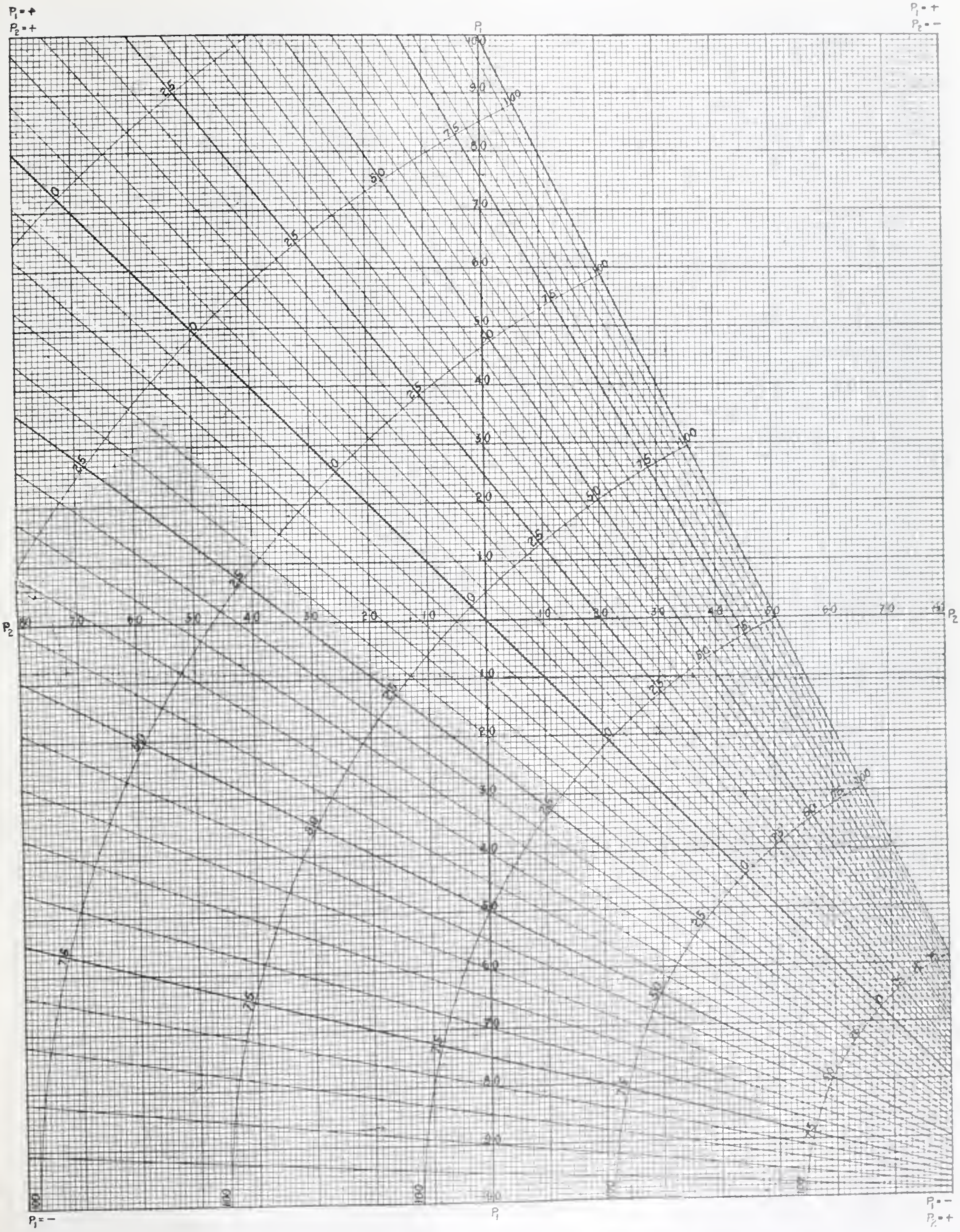
Starting at the center (or origin) where the heavy lines cross, move straight to the right (along the horizontal axis) 14.3 spaces, thence straight up (parallel to the vertical axis) 10.4 spaces. The point arrived at is about seven-tenths of the distance from the diagonal line marked zero to the diagonal line marked five, and is below the zero line. The per cent of change in the train load should, therefore, be an increase of about 3.5 per cent.

This simple operation not only checks the three computed percentages, but is also a close indirect check on the two computed figures for net ton miles per train mile. The operation of the chart can be mastered with a very little practice; and by interpolation to tenths between the diagonal lines, the reading on the chart, will never vary more than two-thirds of 1 per cent from the correct calculated figure. A very slight mistake in any one of the four computed figures on which the final percentage depends will change this final figure more than two-tenths of 1 per cent. Any variation of more than two-tenths of 1 per cent is at once investigated. Errors of a smaller magnitude than this are negligible.

In constructing the chart, all the diagonal lines representing fixed values of P, the final percentage, start at a limiting point where both of the first two percentages are minus 100. This is natural; for, if both the basic factors on which the average depends decrease 100 per cent (that is, become zero), no computation is possible of the average or its percentage of change, which are thus made "indeterminate."

Another point on each diagonal line is fixed by the fact that these lines cross the heavy horizontal line at equal intervals. Thus the diagonal line along which P is always an increase of 25 per cent, crosses the horizontal axis 25 spaces to the right of the center. The logic of this may be seen if we consider that with no change in train miles, for example, the train load will follow fluctuations in net ton miles exactly. Or, mathematically, if P (per cent change in train miles) is zero, we can only move backward or forward on the horizontal axis; and if the train load is to vary exactly with changes in net ton miles, the diagonal line with value 30 must cross this axis at value 30, and so on.

It should also be noted that when the two basic figures show identical increases or decreases, the chart will give a reading on the zero line. This is simply another way of saying that when net ton miles and train miles increase in the same proportion, the train load is stationary.



Percentage of Change Chart.

Where comparative figures are given for two years and one item is divided by the second to obtain a derived unit, and where the percentage of increase or decrease of the first and second item are known, the percentage of increase or decrease of the third or derived unit, can be read from the chart. Read the percentage of increase or decrease of the first item (P1) from the center of the chart along the vertical axis, and from this point move parallel with the horizontal axis to the left the amount of the percentage increase of the second item (P2). The point found related to the diagonal lines will show the percentage increase of the third or derived unit (P). Increases for P1 are measured up, and decreases down. Increases for P2 are measured to the right, decreases to the left. All points to the right or above the diagonal zero line give plus values for P. All points below or to the left of the line give minus values for P.

Progress Report of Am. Soc. C. E. Development Committee

At a meeting of the Board of Directors of the American Society of Civil Engineers held June 16 at Minneapolis, Minn., the Committee on Development submitted its second progress report. The basis of the report is the work of the four sub-committees which were appointed at the November meeting. Inasmuch as the report contains certain fundamentals which the committee anticipates will form the basis of its ultimate report, it is reprinted below:

A. RELATIONS WITH OTHER NATIONAL SOCIETIES AND RELATED ORGANIZATIONS.

It is the opinion of your committee that the identity of the four existing national societies should be preserved.

The committee believes that the American Society of Civil Engineers should continue to pursue the objects for which it was formed as expressed in the constitution, namely:

"The advancement of engineering knowledge and practice and the maintenance of a high professional standard among its members" and that it should devote its chief endeavors to the performance of these objects. It feels, however, that the time has now came when this society should adopt the principle of becoming an active national force in economic, industrial and civic affairs. This can only be done effectively, however, by active co-operation with other engineering organizations of the country.

To this end the committee recommends that a comprehensive organization be formed embracing:

First—The local affiliation of the branches of the national technical societies and the local technical societies.

Second—A state council composed of representatives from the local affiliations.

Third—A national council consisting of representatives of the national technical societies and of the state councils or state group organizations in lieu thereof.

The object of the council shall be to increase the usefulness of the engineering profession, to bring about greater co-operation and to advance the welfare of engineers.

The council shall have an executive committee, shall maintain a central office and shall hold at least one meeting each year. It would be desirable that a bulletin of general engineering interest be published by the council. The council shall be supported by a per capita contribution or in such other manner as may be determined.

B. INTERNAL RELATIONS AND LOCAL ASSOCIATIONS.

Your committee makes the following recommendations:

Local Associatons.—(a) That every member of the society be a member of a local association.

(b) That there be created in each geographical district of the society an organization consisting of representatives of the local associations in that district.

(c) That local associations and district organizations shall operate under uniform constitution provisions to the extent only that the same are necessary or desirable to insure uniform relations with the society.

(d) That the representatives of each district on the board of directors and the nominating committee of the society be elected by ballot by the corporate members resident in such district.

(e) That it be the duty of each director to visit each local association in his district at least once during each calendar year.

(f) That the nominating committee select candidates for the offices of president, vice-presidents, and treasurer, the election of which officers shall be by the ballots of the corporate members.

(g) That there be an annual conference of representatives from the local associations for the purpose of discussing the welfare of the society and its members.

(h) That there be allotted a percentage of the dues of the society to each district organization and each local association for the payment of their expenses.

(i) That the board of direction refer, for recommendation, each application for membership to the local association in whose jurisdiction the applicant resides.

(j) That the present provisions of the constitution relating to the discipline and expulsion of members be so revised as to make them more effective.

(k) That it be the obligation of each local association to bring about within its territory a close affiliation of all branches of the national and of the local technical organizations for the purpose of advancing the status of the engineer.

(l) That in communities where members are too few to form a local association, it be their obligation, in addition to that of their district local association, to affiliate with the resident members of other technical societies, and other engineers, where such affiliations will promote the organization to a local affiliate body.

(m) That the local affiliations be the basis for comprehensive state and national organziation.

Rearrangement of Grades.—That the grades of membership be more clearly defined and that changes be made in the grades of associate and fellow.

Student Societies.—That it be the duty of the local associations to organize and assist student engineering societies in neighboring engineering schools, to provide carefully selected speakers, and to maintain personal contact with such societies.

(Note: The above is recommended in lieu of establishing the grade of student member and of establishing student branches.)

Young Men of the Profession.—That it be the duty of the local associations to provide for the welfare of the younger members of the profession by:

(a) Reasonable representation on the active committees.

(b) Encouraging their discussion of the general problems of the society.

(c) Arranging excursions to works of engineering interest, and

(d) Promoting social intercourse between them and the older members.

Personal Service.—That a personal service bureau be maintained by each local affiliation, so organized as to operate in connection with a central service bureau to be maintained by the national council.

American Engineers in Foreign Service.—(a) That it be the duty of members resident in foreign countries outside of North America to form associations and to promote an affiliation with the resident members of other American technical societies.

(b) That the board of direction consider the feasibility of keeping on record, and providing to American consuls abroad, the names, addresses, and brief professional qualifications of members of the society resident abroad.

C. TECHNICAL ACTIVITIES.

Meetings.—That local associations should hold not less than four stated meetings per year and encourage joint meetings with kindred societies.

That the fornightly meetings of the parent society should be discontinued.

That the semi-annual meetings of the parent society should be supplemented by the addition of a spring and a fall meeting held successively in different sections of the country under the auspices of a local association.

Papers.—That the present system of securing papers depends wholly upon voluntary offers and results in a limited variety of subjects. Committees of the parent society and local associations should be formed and charged with the responsibility for promoting greater activity and discussions. Simultaneous discussions of important papers by local associations is desirable.

That the use of the monthly proceedings should be extended to include editorial work, abstracting and reviewing important engineering articles and subjects of popular interest to the great majority of engineers.

Committees.—That there be created advisory standing committees of the board to promote the study of important engineering subjects and charged with outlining and co-ordinating the work of like committees of the local associations. Three members of the board should constitute a standing advisory committee on each subject. Local associations should urge the younger members to identify themselves with local committee work.

That local associations should suggest names of volunteers possessing necessary qualifications for special committee service, and that tenure of committee membership shall terminate automatically on account of absence or inactivity.

That the society support an active program of research work, co-operating, if practicable, with existing research agencies.

That the chairmen of the standing advisory committee of the board should constitute the publication committee.

That to effectively carry out the intent of these recommendations, a technical editorial staff under the direction of the publication committee should be established.

Sections or Divisions of the Society for Specialized Lines of Work.—It is not recommended that the work either of the parent society or the local association be divided in this way. The object apparently sought by such divisions will be better met by the work of strong committees.

Co-operation with Specialized Engineering Societies and Other Organizations.—Much of value has been accomplished in the past in this way and it is recommended that such work be continued and extended.

Standards in Engineering Practice.—There exists at the present time a committee known as the American engineering standards committee, composed of representatives of the national engineering societies. This line of co-operation and advice is approved and it is recommended that it be continued and extended but the idea of developing this committee into another association is deprecated.

It is recommended that a book of recommended practice and standards be compiled which will be revised periodically to follow the development of engineering.

D. RELATION TO PUBLIC AFFAIRS.

Definition of Engineering.—That the three main ideas in a complete definition of engineering should be as follows:

(a) A general and descriptive statement.

(b) The content of the profession—the things that engineering does.

(c) The aims and motives the profession should have.

Ethics.—That a short code of ethics of broad scope, general character, and positive rather than negative injunction be prepared.

Engineering Education.—That a standing committee of seven be created to consider questions of educational policy, and offer advice and guidance in carrying out such policy. The aims of engineering education, fundamental requirements, changes in curricula, indicated by changing social and industrial conditions, the qualifications of teachers, and the standardization of degrees are a few of the topics which such a committee should rightly consider. Further, that local associations appoint similar committees of three or five to co-operate with educational institutions in their respective territories.

Licensing.—That the society in co-operation with the other founder societies prepare a standard form of bill for the licensing or registration of engineers, to be used in the framing of legislation.

Arbitration and Expert Testimony.—It is the belief of the committee that the present practice with regard to expert testimony and arbitration is not satisfactory, and it is recommended that a committee of the American Bar Association be asked to co-operate with the joint committee from the four founder societies in order to develop better practice along these lines.

Publicity.—It is recommended that the preparation of general articles on engineering subjects be encouraged and assisted by the profession, especially with a view toward having such articles published in the standard magazines.

Legislation and Development of Natural Resources.—It is recommended that the national council maintain an agency in Washington, D. C., or elsewhere, for the purpose of keeping advised of all proposed federal legislation and departmental rulings and regulations involving directly or indirectly questions of engineering; and that such agency keep the society or its locals advised from time to time of such matters. It shall also be the duty of the various locals to keep advised on all proposed state legislation affecting engineering matters and the said locals shall actively interest themselves to the end that proper legislation may be enacted. It is also recommended that such agency and the state and national councils shall keep advised as to the proposed creation of federal and state commissions, whose activities may affect engineering enterprise; and that the influence of the locals and the society at large shall be directed towards securing the appointment of engineers upon such commissions.

The Service of the Engineer to the Community, State and Nation. The engineering profession owes a duty to the public which it is believed can best be discharged by the active participation of every engineer in the civic work of his locality. To this end it is urged that the engineer join the civic body of his community, and if there be no such organization, that he should then endeavor to organize the community for civic work in sympathetic co-operation with the governing body. The engineer's duty to the public also requires that he give his best efforts to matters of state, interstate and national character, calling upon the various engineering bodies for assistance and co-operation when necessary.

Patent Law.—Inasmuch as a nation-wide society of inventors has been formed, composed largely of engineers, one of whose objects is to handle the subject of patent law, it is recommended that no action be taken on this subject at the present time.

Co-ordination of Government Activities.—It is recommended that the influence of the entire membership of the society be directed toward the creation of a federal departmnt of public works, the secretary of which shall be technically qualified and a member of the president's cabinet, and that the law creating such department shall provide for the co-ordination of all Government engineering activities.

Industrial Affairs.—That fundamentals of industry and their inter-relation are based on engineering principles which should form a part of the education of the engineer.

Cost of Hetch Hetchy R. R.

The Hetch Hetchy R. R., built by San Francisco, Calif., for the primary purpose of transportation of materials for the construction of its Hetch Hetchy water supply project, was in operation during the fiscal year ending June 30, 1918. The railroad is a single track line about 68 miles in length.

Due to financial difficulties encountered by the contractor, who was unable to complete his contract under the provisions of the specifications, a provisional acceptance of the railroad was made, with the understanding that the city would complete it, deducting from the final payment thereto the actual cost of completion. The principal work which the city undertook under this agreement was ballasting the roadbed.

At the beginning of the past fiscal year, the amount that had been expended on the railroad was $1,437,411. During the past fiscal year, the track laying was completed to Hetch Hetchy Damsite, and the total estimated amount due the contractor was $1,613,178.

The itemized account of the work performed by the contractor, according to the annual report of M. M. O'Shaughnessy, City Engineer, for the year ending Nov. 30, 1918, was as follows:

Grading, excavation	1,161,997.2	cu. yds.	$ 0.67	$ 778,538
Grading, overhaul	476,542	sta. yds.	.01	4,765
Culverts, 12-in.	3,249	lin. ft.	.90	2,924
Culverts, 24-in.	11,892	lin. ft.	1.75	20,811
Culverts, 30-in.	1,306	lin. ft.	2.50	3,265
Culverts, 36-in.	2,106	lin. ft.	3.15	6,633
Fencing, common	6.291	miles	600.00	3,774
Fencing, hog-tight	31.801	miles	670.00	21,306
Ballast:				
Sec. 4 gravel*	1.042	miles	562.08	585
Sec. 5 gravel	13.165	miles	1,503.65	19,795
Sec. 5 gravel	1,000	cu. yds.	.85	850
Track Construction:				
Track laid	70.130	miles	8,450.00	592,598
Switch sets	27	sets	140.00	3,780
Guard rails	2,824.2	lin. ft.	.62	1,751
Point castings	780	lbs.	.065	50
Rail braces	2,702	pcs.	.33	891
Anti-creepers	1,665	pcs.	.21	349
Derails	5	pcs.	15.00	75
Cattle guards	60	pcs.	15.00	1,200
Redwood water tanks	6	pcs.	400.00	2,400
Tuolumne River Bridge:				
Truss	487,121	lbs.	.053	25,817
Girders	73,562	lbs.	.052	3,825
Trestles, lumber, erect.	670.592	ft. M B M.	40.00	26,823
Iron in trestles	42,694.87	lbs.	.05	2,134
Masonry, concrete	1,492.512	cu. yds.	12.00	17,910
Dry rubble	134.9	sq. yds.	2.00	269
Telephone line complete	50.363	miles	575.00	28,958
On poles already set	7.878	miles	380.00	2,993
Station insts. installed	10	sets	16.00	160
Extra work:				
At Station 2924-50, driving 7-ft. tunnel, 130 ft. at $13				1,690
Excavating portals, 235 cu. yd. at $1.50				352
Force account bills pertaining to railroad work only				34,896
				†$1,612,178

*40 per cent complete. †This amount does not include $190,630 paid in 1915 for grading 9 miles of roadbed from Hog Ranch to Hetch Hetchy.

News Letter

St. Louis Items.

The L. J. Smith Construction Co. of Kansas City were awarded the contract for filling five bridges on the White River branch of the Missouri Pacific R. R., near Hollister, Mo. These bridges average 80 ft. high They are shipping one shovel, four locomotives, 42 16-yd. cars, a spreader and 10 boarding cars on this job. Have a year to finish it in. Scott and Clarence Mitchell will be in charge of work.

J. W. McMurray Contracting Co. of Kansas City are going to put in about 1,000 yd. of reinforced concrete on the L. J. Smith Construction Co. job on the White River branch of the Missouri Pacific R. R.

W. A. Ross of Kansas City was awarded 5 miles of bituminous macadam road work from Home St. south to Red Bridge road, just outside of Kansas City.

J. W. McMurray is tearing down an old 4-story apartment house that he owns at 15th and Harrison St. and putting up a modern concrete garage. Doing the work himself.

C. R. Cummins Co., Cleveland, Ohio, were awarded contract for building belt line around Detroit, Mich.

The Crane Construction Co., Eureka Springs, Ark., can use some 5 to 10-team outfits on State Highway construction near that point.

Ward Bros. have their outfit at work on a big reservoir at Bellevue, Ohio.

W. A. Gierke has finished his job on the Burlington R. R., near Ayers, Ill., and moved on to a new job at Weston, Mo.

The Fred R. Jones Co., of Chicago, is constructing the pump house and laying pipe for the new big reservoir at Bellevue, Ohio.

Cameron, Joyce & Co., 17 S. 7th St., Keokuk, Ia., have about 30,000 yd. of good machine work in Tazwell County, Ill., to sublet. They state they can pay a good price for this.

Frank Cook has moved Mrs. Eby's outfit on to a county road job near Lincoln, Neb., that he subbed from Cook & O'Brien.

A. D. Thompson & Co., 1005 Jefferson Bldg., Peoria, Ill., have 15,000 cu. yd. of excavation and about 29,000 cu. yd. of borrow on road work just north of Green Valley, Ill., to sublet. They are offering 33 ct. for borrow and 45 ct. for excavation.

M. Hayes & Sons, Montrose, Ill., have between 40,000 and 50,000 cu. yd of wheeler and fresno work to sublet.

Cook & O'Brien, Kansas City, Mo., were awarded 3 miles of county road work near Lawrence, Kan. Their figures are in the neighborhood of $120,000 for this job.

E. C. Freemole has started a machine outfit on the Lancaster county road work near Lincoln, Neb. Freemole subbed this job from Cook & O'Brien, of Kansas City.

J. E. Lyman, another one of the good old time contractors, has passed away. Lyman died here of heart disease on Monday, June 16th, at the age of 71 years. Lyman, in his day, was probably one of the best known and popular contractors in this part of the country.

P. J. Murphy informs us that his work on the Wabash has shut down temporarily. He has 12 teams in the pasture that he would like to place on some work in this part of the country.

Newt. Paisley has been appointed manager of Koenig Labor Agency in Kansas City, vice Chas. A. Peppers, resigned. Contractors when in Kansas City are invited to come in and get acquainted with Newt. He can post you on all new work in that part of the country.

Mulvill Bros., Alton, Ill., have a dandy job of railroad work to sublet suitable for an 8 or 10-team outfit.

Stresenreuter-Cotton & Co., 860 Old Colony Bldg., Chicago, Ill., have 100,000 yd. of grading on State Road work just outside of Effingham, Ill., to sublet. This work runs about 25,000 yd. per mile and considered a very fine piece of team work.

The assets of the Southern Traction Co., of Illinois, were sold at auction in East St. Louis to Claude K. Rowland, an attorney representing H. D. Mephan, original promoter of the road, and several New York capitalists, for $400,000, on July 10th. A plan to extend the lines to a majority of the larger towns in south Illinois eventually reaching Cairo was announced.

A. B. KOENIG.

Personals

Albert M. Traugott has been appointed acting chief engineer of the Virginia R. R., with headquarters at Norfolk, Va.

The Aberthaw Construction Co., of Boston, Mass., has opened a permanent office in Atlanta, Ga., which will be under the direction of N. McL. Sage.

D. K. Orr, formerly assistant chief engineer, has been appointed superintendent of the Monongahela R. R., with offices at Brownsville, Pa. The duties of assistant chief engineer will be assumed by G. H. Burnette, assistant engineer.

The American Engineering Service Co., of 122½ State St., Beardstown, Ill., has been organized with W. W. Phillips of St. Louis, as president, and L. A. Cormick, St. Louis, as secretary, and will engage in a general engineering and construction business, specializing in public utility work.

Lieut. Robert J. H. Worcester, having been discharged from the Army May 6th, has returned to his former position as engineer and superintendent of Roads and Bridges for the Town of Concord, Mass., June 1st. Lieut. Worcester served with the 42nd (Rainbow) Divisional Engineers at St. Mihiel, the Argonne and in the Army of Occupation.

George Ellery Hale, director of the Mount Wilson Observatory and foreign secretary of the National Academy of Sciences, who has been for the last 10 years a correspondent of the Academie des Sciences, Institut de France, has received the unusual honor of election as Associe Etranger, taking the place of Adolph von Baeyer, declared vacant by the Academy. The Foreign Associates are limited to twelve, and the high distinction has been held by only two Americans—Simon Newcomb and Alexander Agassiz. The National Research Council, upon the presentation and acceptance of Dr. Hale's resignation as its chairman and the election of James R. Angell as his successor, created and bestowed in perpetuity upon Dr. Hale the title of Honorary Chairman in recognition of his services to the National Research Council.

Clifford M. Holland, chief engineer of the Hudson River Vehicular Tunnel Commission, 115 Broadway, New York City, has announced the following additional appointments to the engineer staff: George S. Yeomans, 24 Northfield Ave., West Orange, assistant designing engineer; Joseph C. Imhoff, 130 Bostwick Ave., Jersey City, architectural draftsman; Major Charles S. Gleim, Camp Eustis, Va., chief of party; Henry G. Babcock, Fanwood, instrument man; George B. Heilner, 548 North Broad St., Elizabeth, level man; Anson B. Moran, Bernardsville, rodman, at $1,200; Victor J. Smith, 301 Webster Ave., Jersey City, rodman; Oliver Newman, Belmar, draftsman; Henry J. Sackender, 55 Second St., Weehawken, draftsman, and L. A. Francisco, 422 Bergen Ave., Jersey City, draftsman.

Industrial Notes

E. A. White is leaving as the head of the Division of Agricultural Engineering, University of Illinois, and on Aug. 1 will be connected with the Holt "Caterpillar" Tractor Co. at Peoria, Illinois, as Chief of its Research Division.

The Dewey Cement Gun Co. has been reorganized and its name changed to Traylor-Dewey Contracting Co. The officers are: S. W. Traylor, Chairman Board of Directors; C. L. Dewey, President; W. J. Roberts, Vice President; H. B. Battersey, Treasurer; F. W. Hopkins, Secretary; R. H. Gillespie, General Manager and Chief Engineer; B. C. Collier, Consulting Engineer, and W. L. Stancliffe, General Superintendent.

The Blaw-Knox Co., Pittsburgh, Pa., announces the appointment of L. C. Murray to its corps of engineer-salesmen, in the "KNOX" department. Mr. Murray, a graduate of Penn State College, was for many years connected with the Carnegie Steel Co., both at the Edgar Thompson Works, Bessemer, Pa., and in the sales department. His activities will, for the most part, be devoted to the steel plants in the Pittsburgh district.

The Holt Manufacturing Co., of Peoria, Ill., builders of "Caterpillar" tractors, announces the appointment of Fred W. Jones as advertising manager, effective July 10, 1919. Mr. Jones goes to the Holt Co. from the advertising department of the International Harvester Co. of America at Chicago, where for the past eight years he has had charge of the copy for farm, trade and newspaper advertising placed by that firm, and has taken an active part in the development of their sales force.

The Massey Concrete Products Corporation, Peoples Gas Bldg., Chicago, announces the following appointments: Paul Kircher, resident manager, of the eastern district, including Eastern Canada, with headquarters at 50 Church St., New York; G. H. Redding, resident manager, in charge of sales in the central district, with headquarters in Chicago; H. E. Burns, resident manager, in charge of sales in the southwestern district, with headquarters in the Sumpter Bldg., Dallas, Tex.

The Chicago Pneumatic Tool Co. announces the appointment of L. C. Sprague, formerly district manager of sales at New York, as manager of western railroad sales, with headquarters at Fisher Bldg., Chicago, and H. G. Barbee as manager of eastern railroad sales, with headquarters at 52 Vanderbilt Ave., New York City. Nelson B. Gatch, formerly district manager of sales at Chicago, has been appointed district manager of sales at New York, succeeding Mr. Sprague. Announcement of Mr. Gatch's successor at Chicago will be made later.

The Corrugated Bar Co., Inc., of New York, announces that it has taken over the entire assets and liabilities of the Corrugated Bar Co., a Missouri corporation, and is continuing the business of the latter company, which is in process of dissolution. This means the retirement by purchase of the Garrison interests, which held the majority of the stock of the Missouri corporation from its inception, in 1891, until the recent reorganization. The control now passes to A. L. Johnson, who has been connected with the Company since July, 1895. The officers and board of directors of the new corporation are: A. L. Johnson, President; W. H. Kennedy, Vice Pres. and Treas., Ralph McCarty, Secretary; A. E. Lindau, Gen'l Mgr. of Sales; Lyman Bass, Counsel.

WANTED

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials

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How Political Economy May Become a Science

The engineer who delves much into literature on political economics is impressed with the deluge of theories and the scantiness of data. Current periodicals are quite as unsatisfactory as the classical treatises on this branch of knowledge. When an engineer thinks of economics he thinks of costs and values; but the typical writer of papers on political economics seems to think mainly of theories. Does he discuss the distribution of wealth, then look for a dissertation on the "single tax theory" or the like. Occasionally he may show signs of regret at his lack of data, amid his abundance of phrases, as witness this paragraph from an article by William Kent on "Land Tenure and Public Policy" in the Yale Review:

"I wish some young man with a head for figures would spend a year in discovering how much unearned rent goes into the cost of a ham that the man who is digging in the city sewer would like to buy, if he had sufficient wealth. Farm, stockyard, railroad, and city tenancy would all contribute their quota."

To Mr. Kent's modest wish we add the more ambitious hope that many a young engineer, "with a head for figures," will apply engineering science in the writing of worth while literature on political economics. For more than a century the world has been flooded with pamphlets, papers and periodicals on political economy written by men gifted with the gift of tongues but without "the head for figures." They have pumped our libraries full of dilute theories of an unscientific sort. The term "economics" has come to be almost a synonym for long-winded babble and angry debate. Economics, of all words, thus to degenerate!

Professors who could not correctly interpret a balance sheet, much less solve a simple cost equation, have set themselves up as teachers of the most complex business, the business of government. Such facts as they use in their arguments are usually non-statistical and therefore of little if any worth in solving an economic problem. Very frequently their "facts" are not even half truths, often picked up from a source whose reliability they never have questioned. Thus in the article by Mr. Kent, above referred to, we read:

"In city and country alike, speculative land holding has warped the progress of orderly development. In Seattle an interurban company deliberately raised its round trip fares from 15 to 40 ct., and thereby destroyed all value in a large working people's settlement. The same outfit, by a deliberate shift of transportation facilities, changed the values in the center of the city so as to favor real estate which it speculatively held."

The editor happens to be familiar with the case mentioned by Mr Kent, and knows that he misrepresents the facts, doubtless without intent. But this very

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

honesty of purpose and sincerity of utterance make all the more reprehensible his carelessness. But it seems to be habitual with the non-scientific writer to be careless about his data so long as his utterances are striking and his sentences well polished.

Quantitative facts are dug out of experience, and the digging is both tiresome and costly; whereas verbiage is easily spun out of the imagination, and fills paper as completely as it it were reliable data. Engineers and scientists are trained to dig. Most political economists are trained to talk, and the weight of their pages already sags the shelves of 10,000 libraries. Let engineers that have the ability to talk as well as to dig, undertake to make a real science of political economy.

Some Fallacious Arguments for Municipal Ownership

There is no doubt that municipal ownership of public utilities is increasing in America, in spite of the fact that it has not been demonstrated to be more economic than private ownership. Has the force of British and European example lead to this result? Is it because of the spread of socialistic doctrines? Neither foreign example nor socialism seems to account for the trend toward municipal ownership. Americans are not given to following foreign precedents, and with only one socialist in Congress it can hardly be said that socialistic propaganda has led nearly one-third of all "central station" electric plants to fall into the hands of municipalities.

The cause of this drift toward municipal ownership is, like every cause, a plurality of forces and not a single force. One of the main forces at work is the desire of political office holders to wield more power. Contributory to the effect —municipal ownership—is the prevalent ignorance of the principles of economics. Even engineers and other educated men are so commonly ill-informed in economics and so poorly trained in logic that they are easily deluded by the specious arguments and the data presented in favor of municipal ownership.

In a recent issue of American Municipalities, G. C. Long, city manager of Webster, Iowa, urges municipal ownership of electric light and power plants. He summarizes his conclusions thus:

"In drawing this paper to a conclusion I wish to state a few points that apply not only to our particular case, but to municipal ownership in general.

"1. We (in Webster) have not experienced the inevitable conflict between private ownership and public welfare which made itself so manifest in the past year.

"2. We did not find it necessary to increase our rates on account of the war.

"3. We do not have to pay dividends on watered stock.

"4. We do not have to pay interest or dividends at all. The people enjoy the benefits by a direct reduction in rates.

"5. We have lower rates than any privately owned steam plant in the State of Iowa.

"6. We do not operate to make enormous profits and what profits we do accumulate, go into the public funds for the benefit of the commonwealth instead of into private pockets.

"7. Last, but not least, I believe that because of municipal ownership we have better social and industrial conditions. We pay better wages, have shorter hours and have more progressive improvements of labor, than is found in private ownership. Further because the people derive directly the benefits of municipal ownership the resultant effect is the diffusion of a wealth to which the people are justly entitled."

"If it is right for municipal ownership of one utility then it is right that a municipality should own the others. One of the great advantages of a municipally owned plant for us is the co-ordination of our public utilities, as our water works system is operated in conjunction with our light plant, though both are maintained separately, yet the economy and service rendered in the combination is very valuable."

Note particularly Mr. Long's item 4, "We do not have to pay interest or dividends at all." Elsewhere in his article he says:

"A still further advantage makes itself manifest when we take into consideration the fact that when the interest bearing indebtedness of municipal plants is being paid off, the interest to be paid falls off in direct proportion. A public plant does not have to pay interest after the plant is once fully paid for. This is an advantage for municipal ownership which is apparently impossible for a private plant to meet."

He states that although the 15,580 municipal electric plants in America represent an investment of $77,000,000, there are only $31,000,000 of oustanding bonds on which interest must be paid; and his argument is that the rates charged for electricity need not be high enough to pay interest on the remaining $46,000,000 invested in the plants.. This is economic sophistry of the worst sort.

So long as money commands interest, interest should be charged against every investment, whether public or private, and prices or rates should be high enough to earn interest on the entire investment. Otherwise there results inequality of benefits to the rate payers. Let us take an extreme case to make clear this point. Assume a small growing city, in which the investment in the electric plant has been completely amortized, and in which the power plant has excess capacity for present needs. Now let some manufacturer sell his steam plant and substitute for it all the excess electric power that the city has. The manufacturer would thus escape paying interest on the city's power plant that he would use; but in a short time, due to growth, the city would have to build additional plant. The interest on this additional plant would be spread over all consumers, to the advantage of the manufacturer.

Any number of similar illustrations can be given to show the inequity of rates that do not include a proportionate charge to cover interest on the plant. But perhaps a more striking demonstration of the inequity is had from a consideration of the question of amortizing an investment. When bonds are amortized out of earnings, whose money is used to retire the bonds? Evidently the money of the rate payers. If those rate payers are to be always the same people, year after year, till the blast of Gabriel's horn, there might be no inequity in retiring the bonds with their money and thereafter charging them lower rates. But if not—if those rate payers are to change or to die—then every dollar taken from them to amortize the investment in a plant to be used by other people is a dollar unjustly extorted.

Slipshod reasoners speak of "the public" as if it represented an unchanging aggregation of human beings; whereas each member of "the public" should be regarded as a stockholder in public utilities to the extent that he has contributed money to pay for them, whether the payment is by taxation or by rates high enough to amortize the investment prior to the end of its useful life.

Having established a false economic method of rate making, by eliminating interest charges on at least part of the plant, it should be easy for the advocates of municipal ownership to show lower rates under municipal than under private ownership. Mr. Long says:

"In investigating the rates charged for electric light and power, I find that the rates for municipal ownership are from 10 per cent to 20 per cent lower than for private ownership. In covering the whole field it is found that the average rate is 1.39 ct. per K.W.H. less for municipal than for private ownership. The total output by private companies is approximately 11,000,000,000 K.W.H. per year, and the saving would be over $150,000,000 annually if this current were purchased at the present average rates under municipal ownership."

On the face of it this looks quite favorable to municipal ownership, but, according to Mr. Long, the municipal plants pay interest on but slightly more than 40 per cent of this cost. The investment in private electric plants is about $2,100,000,000—or 28 times that in municipal plants—and if 60 per cent of that investment paid no interest, then, at 6 per cent interest, the private plants would save $75,000,000 a year, or half the alleged saving that Mr. Long claims would occur were the rates of private plants lowered 1.39 ct. per K.W.H. This would still leave an apparent saving of $75,000,000 a year by adopting municipal ownership, or about 70 ct. per capita per annum, or one-fifth cent per day per person. Even the entire saving of $150,000,000 a year claimed by Mr. Long is only two-fifths of a cent daily per capita!

We call this "an apparent saving" that might be effected by municipal ownership. There are several reasons why it is not a real saving. First, it is notorious that municipally operated plants do not ordinarily show all the real operating expenses in their accounting statements. Usually they have an inadequate charge for depreciation, and frequently none at all save the little that occurs in current maintenance expenses. Second, many municipal plant employes occupy public buildings without rent. Third, municipal plants pay no taxes, which alone wipes out one-third the "apparent saving" that Mr. Long claims.

Finally, the average price of electric current had steadily and rapidly fallen for 33 years until the world war. This is attributable mainly to the invention of more economic plant, to aggressive and better business management, and to better load factors resulting therefrom and from the growing use of electricity. The advocates of municipal ownership claim that municipal competition was the main factor in lowering electric rates, but the fact is that average rates fell almost as rapidly in cities without as with municipal competition. Public service commissions have also forced lower rates, and in this respect have been a far more important factor than municipal competition.

Although 31 per cent of the "central station" power plants are municipally owned, only 3 per cent of the total capital is invested in municipal plants. It is the small cities that lean most strongly toward socialistic experiments of this sort. Nevertheless there is an unmistakable drift toward municipal ownership. Many politicians favor it. Labor unions advocate it. Socialists shout for it. The Hearst press and other papers of similar character clamor for it. "Public ownership of public utilities" is a slogan that has a convincing ring to it. The fundamental question, however, should be: In the long run is municipal ownership more profitable to the average citizen than private ownership? This question can not be answered by slogans or by specious claims and non-quantitative facts. It can be answered only by cost and profit data. Mr. Long has it to his credit that he does not rely entirely upon talk but produces some figures in his attempt to answer the question. In fact his is the best attempt that we have seen to prove the case for municipal ownership. Yet, when analyzed, his data fail to carry conviction.

The Attitude of Civil Engineers Toward Inventions

"A contemplation of history," says The Chemical Engineer, "reveals how few of the truly epochal scientific achievements are the products of any one mind. Also it appears to be true that the length of time consumed in working out such achievements varies, as a rule, inversely with the number of minds at work upon them." For example, 10 ingenious men will perfect an invention in one-tenth the time required by a single inventor.

Here is a case where "too many cooks" do not "spoil the broth." Invention is a novel combination of old "elements." Each ingenious mind that works on a problem brings to bear certain elements of knowledge possessed by no other mind at work on the same problem. Moreover, a spirit of rivalry tends to stimulate each of a group of men working on the same improvement.

Among chemical, electrical and mechanical engineers there has been more co-operative inventing than among civil engineers, and there has been faster progress in those three branches of engineering than in civil engineering. The most inventive civil engineers have usually worked on their problems alone, or with but slight aid. Altogether too often the inventions of civil engineers have been opposed by their fellow engineers. In fact the inventor of a new pavement, or bridge, or sewage purifier, is invariably forced to fight to get it adopted by municipalities. Then if it is an economic success, he must carry the fight into the courts to collect royalties. If at last the courts sustain his patents, he is apt to see other and inferior designs specified by city engineers. So great is the opposition to the inventor of civil engineering structures that it is questionable whether it is worth while patenting such structures.

We know, of course, the usual argument that is raised against inventions of a civil engineering nature, namely "lack of novelty." The same argument if supported by enough expert testimony would kill almost any patent, for nothing conceived by the mind of man is entirely novel. The inventor of the first process of making paper from wood pulp could have been shown to be merely an imitator of the wasp, for the nest of that insect is made of wood fibre ground to a pulp. And the inventor of the first suspension bridge merely imitated the spider.

Unfortunately there is no distinct dividing line between a new combination that the courts will regard as patentable and a new combination that they will declare "could have been conceived by any one skilled in the art." Civil engineers have too often been very narrow in their attitude toward inventions, regarding any foreshadowing of an invention as sufficient proof that any one skilled in the art might readily have effected the improvement. Had civil engineers been more accustomed to working co-operatively on inventions, and had they been more accustomed to regard an invention as an improved design rather than as a stroke of genius, it is probable that there would have been more fortunes made by civil engineering inventors, and consequently greater progress in the design of civil engineering structures.

Nelson Method of Paying Building Contractors for Bidding

In the long run excessive competition increases prices. If six milk dealers deliver milk over the same routes, the price of milk is higher than it would be were there only two dealers. If, on the average, 10 contractors estimate the cost of each building in detail, the prices of buildings are greater than they would be were there less competition.

J. B. Warrack, president of the Northwest Master Builders' Association, recently said:

"I know of one case where 40 bidders were given plans on which to figure, where five bids would have been sufficient. Forty contractors spent their time on this job, which amounted to approximately $25,000, and took at least five days for each bidder to estimate properly. The material dealers sent 40 quotations on various items to the 40 contractors and probably every sheet metal shop, plumber, electrician, sash and door factory, and lumber yard in the Pacific Northwest was troubled with a dozen requests for prices on the work.

"The time and energy consumed by the contractors and material men in figuring on this work was at least eight times that really required to obtain a sufficient number of competitive bids, and at least 39 of the contractors were out the time and expense devoted to the work of supplying figures.

"There is only one way to correct this vicious system, and that is for the owner or prospective building investor to pay for what he receives, to pay the bidders on his job for the labor in making up an estimate of cost of the work, whether the contract is let or not. The owner or inventors would then get as much competition as he was willing to pay for, and the cost would be met by the proper party in place of being saddled on other people who build.

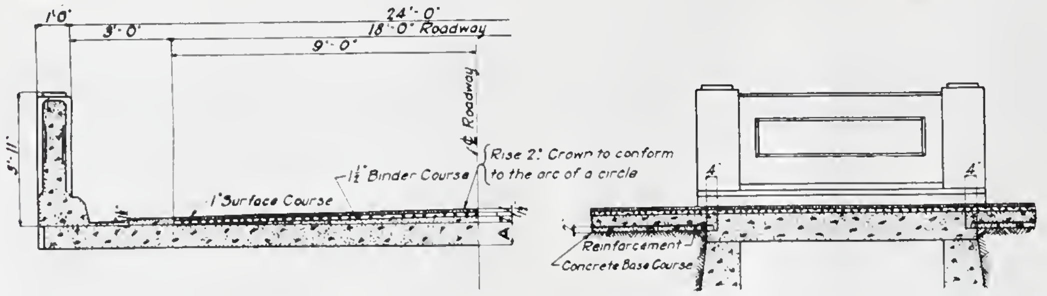
"Personally, I favor the adoption in Seattle of the system of paying contractors for bids embodied in the plan of H. W. Nelson, of Moline, Ill., followed by the contractors in that section.

"The owner or architect calls for bids from such contractors as he desires to compete, then 10 days after the bids are all in, whether or not the contract has been awarded, the owner is obligated to pay each bidder whose bid does not exceed by more than 25 per cent the amount of the bids upon which the contract is awarded, or the lowest legitimate bid if the contract is not awarded, a fee arrived at by taking the square root of the average of all bids received multiplied by seven-tenths. In case the average of bids should be $90,000, the fee arrived at under this system would be $210 for each contractor, not an exorbitant fee for the work involved or for the service rendered.

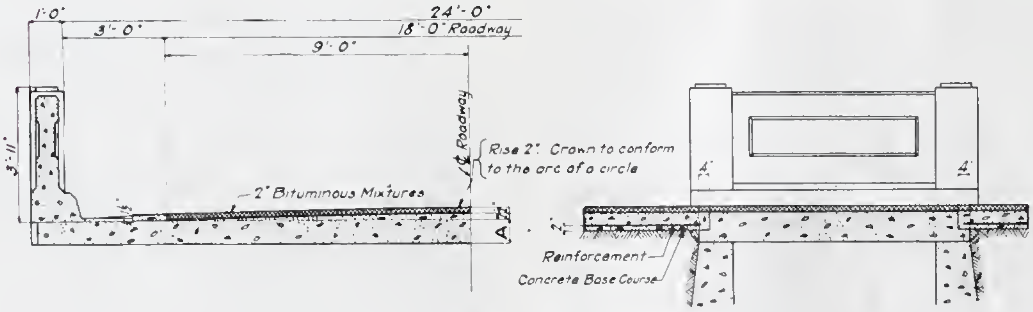
"This system works out so as to cover the contractor's cost of figuring jobs, large and small, without any hardship to the owner."

For many years building contractors have contended that architects should prepare bills of materials for each building, so as to reduce the contractors' expense of estimating the cost. If the Nelson method were universally adopted, it would inevitably lead to the making of a "qantity survey" of each building by the architect or engineer in charge of it, in order to reduce the payment by the owner to each contractor invited to bid.

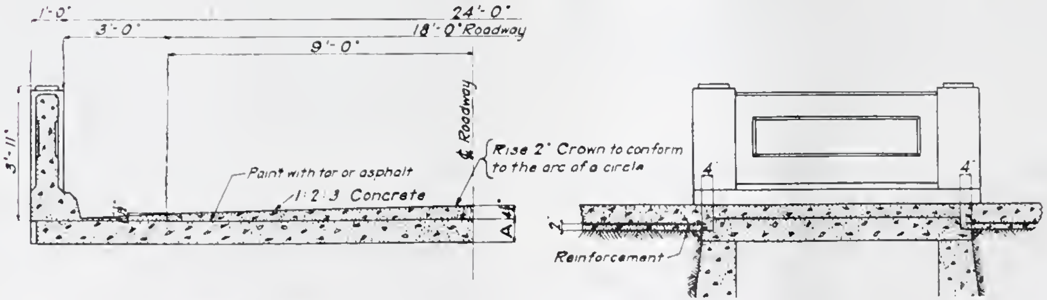
Standard Methods of Pennsylvania State Highway Department for Placing Road Surfaces on Concrete Bridge Floors



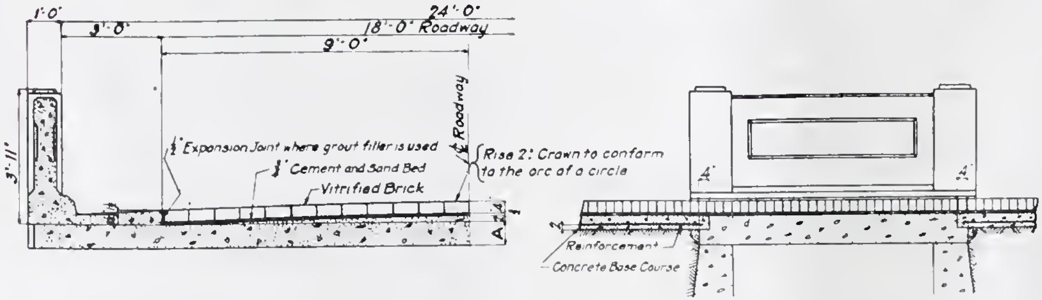
BITUMINOUS SURFACE CLASS A.



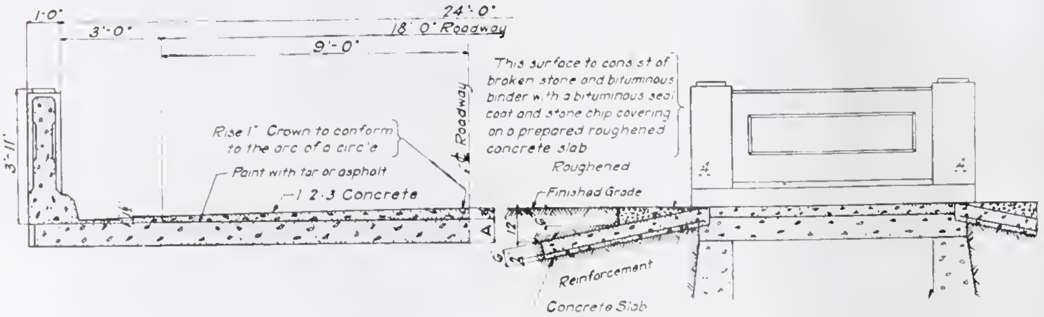
BITUMINOUS SURFACE CLASSES B, C, D, E, F.



ONE COURSE PORTLAND CEMENT CONCRETE SURFACE.



"VITRIFIED BRICK SURFACE"


1'-0"
24'-0"
3'-0"
18'-0" Roadway
9'-0"
℄ Roadway
3'-11"
Rise 1" Crown to conform to the arc of a circle
Paint with tar or asphalt
1-2-3 Concrete
A
This surface to consist of broken stone and bituminous binder with a bituminous seal coat and stone chip covering on a prepared roughened concrete slab
Roughened
Finished Grade
12
6
A
A
Reinforcement
Concrete Slab

ONE COURSE PORTLAND CEMENT CONCRETE SURFACE.
UNIMPROVED ROAD.

Concrete base course in every case on improved road to be reinforced at the direction of the Engineer in order to bridge over any settlement of earth back of abutments. Reinforcement to consist of ½" diam bars 8" center to center longitudinally and 24" center to center transversely. Length of slab to be determined by the Engineer.

When necessary, on unimproved roads, use a reinfored concrete auxiliary slab 6" thick with reinforcement as given above. Length of slab to be determined by the Engineer.

Thickness of floor system "A" to be that shown on standard bridge floor plans for any particular span regardless of type of surfacing used.

Advantages and Disadvantages of Various Methods of Letting Contract Work

By J. A. L. WADDELL.

Consulting Engineer, Kansas City, Mo.

Much has been said of late concerning the different methods of letting contracts; and it appears at present to be a fad to endorse that of cost plus a percentage or cost plus a lump sum. As, in the last three decades, I have tried a number of ways of letting contract work, I deem myself competent to pass an opinion of some value upon the question, and I felt constrained to do so through the medium of your paper.

The most common ways of contract letting are the following:

A. Lump sum for complete construction.

B. Schedule rates for all materials in place.

C. Actual cost plus a percentage, with some kind of allowance for overhead expenses.

D. Actual cost of labor and materials plus a percentage, with no allowance for overhead expenses.

E. Actual cost plus a lump sum, with some kind of allowance for overhead expenses.

F. Actual cost of labor and materials plus a lump sum, with no allowance for overhead expenses.

G. Various methods of profit-sharing between the client and the contractor.

Method A generally appeals best of all to the client, because it fixes in advance what the construction is going to cost him, unless, perchance, there be variations in the estimated total quantities of materials, due to lack of sufficient preliminary information or to the encountering of conditions that could not well have been foreseen. But it is by no means as satisfactory to the contractor, who has to run the risk of being actually out of pocket on the job, in addition to the loss of personal time and effort.

Method B is quite an improvement on Method A, in that the contractor does not have to guarantee the correctness of the estimated quantities of materials; but the prime objection to Method A holds good for Method B, as the latter does not prevent the contractor from losing money on the venture.

Method C is wholly objectionable to the client, in that it places him entirely at the mercy of the contractor and his men. The allowance for over-head may be either an assumed percentage, or the actually computed amount in complete detail, the former being generally the less objectionable. Even if the contractor be perfectly honest and have the best will in the world to keep down the cost for the benefit of the client his employes will not have that desire. In effect they say to themselves and to each other, "What is the use in my exerting myself unduly? The more the work costs the more money the 'old man' makes." I know this to be the case, for some years ago I had to let a large contract for foreign work at cost plus a percentage; and, although the contractors themselves tried to do the honest thing at all times, their men "soldiered" to such an extent that the final cost of the construction was atrociously high, and I had occasionally, on my own responsibility, to discharge some of the contractors' employes, including once their field superintendent. This method of letting work involves asking too much of frail human nature. It is on a par with leaving small sums of money lying around among darkey servants.

Method D involves less labor in cost keeping than does Method C, but, otherwise, it is open to the same general objection.

Method E is almost as unsatisfactory to the client as Methods C and D, except that the contractor's reward for his iniquity is a fixed quantity and not in direct proportion to the extent of that iniquity.

Method F involves a slight improvement on Method E, but only to the extent of a little simplification in bookkeeping and perhaps a reduced opportunity for squeezing the client.

Under the heading "G" a number of methods of profit-sharing have been tried and have proved to be more or less satisfactory. All of them necessarily presuppose a careful accounting of cost from start to finish. Unless the contract between the two parties clearly indicate how every main detail of cost is to be computed, there will be trouble before the work is finished. For instance, in respect to plant—does the contractor furnish it free of charge, or does he receive rental for it, with the rental charged as one of the items of cost of the work? How about paying for repairs and renewals to plant? Who stands the expense of these items—does the contractor, or is it charged as an item of cost of doing the work? Again, if extra work is done under the contract, how is it to be counted in when making the final settlement?

It requires the service of an expert consulting engineer or those of an experienced contractor to draft a contract which will provide, in a manner satisfactory to both parties, for all possible contingencies. With such a contract, however, and with a close system of cost accounting, this method of profit sharing is the most satisfactory scheme for contract-letting which can be evolved.

The best manner for letting contracts on the co-operative basis is a modification of the Graff method. Humorous and captious readers! please do not try to perpetuate a pun by calling it the Graft method; for, in my opinion, it is the most perfect anti-graft one that can be evolved. It is named after the inventor, Mr. C. F. Graff, president of the Graff Construction Co., of Seattle, Wash., and is described in detail on pages 1584 to 1586 of my book on "Bridge Engineering." It consists in guaranteeing a limiting lump-sum expenditure to the client for the work, at which figure for actual expenditure the contractor's profit will be zero (as his total cost and his total payment would be equal), and arranging for a sliding-scale method of dividing any profits there may be (i. e., the difference between the named limiting sum and the actual total cost) on the basis of the client's receiving, up to a certain point, a gradually-augumenting-percentage share of the said profits. Thus the client is protected by bond against excessive expenditure, and the contractor is given the best possible incentive for keeping the cost down to the lowest practicable limit. Naturally, when the client's share reaches one-half of the whole saving, the increment in his percentage should cease, and the two parties should share equally thereafter; for, otherwise, it would involve a hardship to the contractor to deprive him of more than one-half of his profits. It can readily be seen that, if the client's percentage were to keep on increasing, a point could be reached where the contractor would get no profit at all.

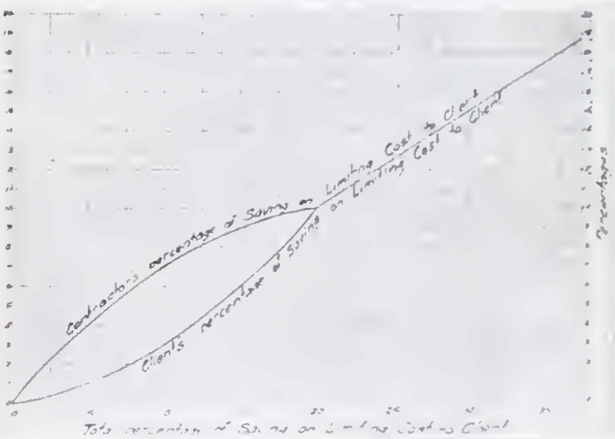


Diagram Showing Basis for Division of Profits Between Contractor and Client.

In calling for tenders, the specifications should indicate preferably by diagram, the method to be adopted for dividing any difference there may be between the lump sum named and the grand-total actual cost of the construction; and each bidder should name a lump sum as the superior limit of his payment, no matter how much larger than it the total cost may prove to be. In comparing bids the only point to consider would be the limiting amounts named; provided, of course, that all the bidders are capable and responsible parties.

The lines on the accompanying diagram are suggested as giving an equitable basis for the division of profits beween contractor and client. An analysis of the diagram shows that when the total saving is 5 per cent, the contractor gets 4 per cent and the client 1 per cent. When it is 10 per cent, the respective shares are 7 per cent and 3 per cent. When it is 15 per cent, they are 9 per cent and 6 per cent, and when it is 20 per cent, they are 10 per cent and 10 per cent. For any greater total saving the shares of both parties are equal.

In order to adjust properly the partial payments as the work progresses, and in order to take care of any increase or diminution in the estimated quantities of materials, the estimated quanties should be listed in the specifications; and each bidder should be required to apply to these such properly-adjusted schedule rates as will make the sum total exactly equal to the limiting cost given in the said bidder's tender If these estimated quantities are found to differ from the actual ones (as they nearly always will), the schedule rates quoted are to be applied to the said actual quantities, and the corresponding total value is to be computed. If it exceed the limit set in the tender, that limit, when making the final settlement, is to be increased so as to correspond with the said total value; but if it be less than the said set limit, the latter is to be reduced by only 80 per cent of the difference between the said set limit and the said computed value. The object of the latter arrangement is to avoid the injustice to the contractor which would be done by failing to recognize properly his overhead expenses, were the reduction in the set limit made equal to the full amount of the difference between that limit and the aforesaid computed value.

Again, if there be extra work done on the contract, of a type not listed therein, the actual cost of labor and materials thereon, without any allowance for superintendence or overhead, is to be recorded; and to it is to be added 25 per cent of its amount to allow for superintendence, overhead and profit. This sum is to be added to the amount of the limit of cost set in the agreement, so as to find the corrected limit to be used when making the final settlement.

I trust that this article may be the means of inaugurating in your columns a thorough discussion of the important question of the best possible method of contract-letting.

Life of Creosoted Piles

The need for creosoting piles to prolong their life and protect them from the ravages of marine borers is well known to engineers. The efficiency and economy of creosoted piles is beyond dispute. Furthermore, it has been shown by experience that some of the first piles creosoted in this country were creosoted in a remarkably thorough and efficient manner, considering how much more we think we know nowadays than was known then concerning the various materials and methods used.

From time to time as structures are demolished to make way for extensive improvements there is afforded an opportunity for observing on a large scale the behavior of treated piles. An instance of this kind is noted in the Electric Railway Journal, from which the following is taken:

A wharf of the Southern Pacific Railroad on San Francisco Bay was removed to make room for port improvements. The wharf was the oldest creosoted pile structure which thus far had been dismantled on the Pacific coast and contained about 14,000 creosoted piles which had been in service for periods ranging from 18 to 29 years. Of these piles, interest centers particularly in 600 which were of Douglas fir, well seasoned before being treated with creosote by the Bethel process in the fall of 1889, and were driven in 1890. Records show that under a pressure of 200 lb. per square inch and a temperature of 260° F., the piles absorbed 14.17 lb. of creosote per cubic foot.

Of these 600 piles, 33 were selected at random for test purposes when the wharf was dismantled. Out of this number 22 (67 per cent) were entirely sound; 2 (9 per cent) had been slightly attacked by borers; 6 (18 per cent) had been severely attacked and 2 (6 per cent) were so damaged as to be unfit for further use. These percentages were typical of the entire lot, it is reported, and about 70 per cent of the 600 are to be redriven just as they are. In fact, this percentage of poles suitable for redriving, it is reported, applies approximately to the entire 14,000 piles. Those not as suitable showed damage only between mud line and high-water mark, and other portions of these piles were in good condition.

The results of this study are believed to confirm the theory that a creosoted pile is absolutely immune from attack of marine borers such as exist in Pacific Coast waters, so long as the shell or portion of the pile impregnated with creosote remains intact.

Magnetic Analysis of Steel

Methods of inspection of high grade steels are far from being perfect. Heating, quenching, and drawing of steel are done in a more or less haphazard manner. Any test which will differentiate without destroying the material between ordinary and exceptional products made from the same stock should be worth very much in the economical and safe manufacture of steel.

Magnetic analysis as a criterion of the quality of steel and steel products was the substance of a paper presented before the American Society for Testing Material, at its 22d annual meeting, held at Atlantic City, June 24-27, 1919.

The paper indicates no definite conclusions but points out a very promising field.

From the large mass of more or less isolated data presented in the paper two important generalizations are brought out:

1. The principle that there is a very close relationship between the magnetic and the mechanical characteristics of steel is established on a firm basis.

2. Laboratory tests show that the commercial application of magnetic analysis to shop routine practice is practicable.

Magnetic analysis may be applied to the study of the effects of heat and mechanical treatments and of the changes that occur during or as a result of alternating, repeated or continued stresses. It may be used to detect the presence of flaws in raw material or in the finished product. It may be used, at least in part, as a method for testing high grade steel products such as cutlery, tools, springs, rails, automobile parts, etc.

The general applicability of this method is limited by the two facts: first, that certain shapes are difficult to test; and second, that more data on the correlation of the magnetic and mechanical properties of steel are still required.

Actual methods of the application of the magnetic analysis are described in detail as used in manufacture of knife blades, and similar cutlery tools, drills, steel rails, ball bearing races and rifle barrel steel. A complete survey of new rails and failed rails was made. The overloading and overstraining action in the straightening of rails between 48-in. supports as compared with the corresponding action when supports 60-in. apart are used was very well brought out in the case of new rails. In a number of instances the experimenters were enabled to locate the interior transverse fissures definitely in the case of failed rails.

Mr. P. H. Dudley in his part of the paper makes the following statement:

Magnetic surveys and analyses furnish a fund of information which cannot be secured by any other method of testing. The fact that the materials can be tested without destruction is of prime importance. It is this feature of magnetic analysis which makes it possible to find in advance those rails which after injury under the straightening press would develop in service into a complete interior transverse fissure.

Mr. C. Nusbaum in recapitulating the work done in these investigations, briefly summarizes the essential points of his paper as follows:

1. That the magnetic properties of a steel are indicative of the transformations which it undergoes with heat treatment.

2. That such properties furnish suitable criteria from which the metallographic structure of such material may be inferred.

3. That no simple relationship exists between the magnetic and other physical properties of a steel product.

4. That by using "limiting values" of suitably chosen magnetic constants the mechanical properties of such a material are uniquely defined.

Method of Checking Shape of Arch Ribs of Bricks.—The shape of the arch ribs for the Bloor St. viaduct at Toronto. Ont., were checked by means of diagrams of the half ribs made for the different spans. These showed the distance between the crown and heel pins as well as the perpendicular distances of all upper and lower chord panel points from this line. The members of each half rib were then laid down, the whole leveled up and the joints drawn tight. A piano wire was then stretched across the pin centers and the shape of the half rib checked by means of the diagram. After adjustments had been made, the rivet holes, which had been punched 3/16 in. small, were reamed to size.

Analysis and Tests of Statically Indeterminate Structures

The analysis of statically indeterminate structures is a very interesting study for the structural engineer. Such structures have been built for many years, but their design has usually been accomplished by the principles of statics augmented by certain simplifying assumptions which had the sanction of good engineering practice, and little attempt has been made to reduce the problem to a strictly scientific basis by the application of the elastic theory or the principle of least work. Just as the triangle is the elemental figure of all truss design, so the rigidly connected frame is the element of design for certain conditions of loading in high building construction, whether of steel or reinforced concrete.

"Analysis and Tests of Rigidly Connected Frames," by Mikishi Abe, has been issued as Bulletin 107 by the Engineering Experiment Station of the University of Illinois.

Dr. Abe makes the following statement with reference to the use and advantage of the rigidly connected reinforced concrete frame:

Use and the Advantages of the Rigidly Connected Reinforced Concrete Frame.—Since about 1905 reinforced concrete frame construction has been extensively used in continental Europe. Many examples can be found in the German texts and magazines. In England also frame constructions of reinforced concrete viaducts and other structures have been built in recent years. There is also a tendency in America to use reinforced concrete frames for buildings and bridges.

The field of the application of rigid frames is almost unlimited, for most reinforced concrete structures are composed of elements of rigid frames. It covers such constructions as buildings, bridge structures, trestles and viaducts, culverts and sewers, subway construction, retaining walls, and reservoirs and water tanks. In these structures rigid connections are used between members and in many or most of them the bending moments are statically indeterminate.

It is clear that every building construction of reinforced concrete may be considered as a rigidly connected frame, for columns, girders, beams and slabs are all rigidly connected with each other, even though the effect of this condition is not fully considered in the design. In continental European countries it is most common to use frames in building constructions, each as roofs, balconies, towers, and the building as a whole. In the design the requirements and the advantages of the frame are taken into account.

Bridge structures are in the field of the rigid frame. Arches, beam and bent construction, and most bridge structures can be designed as frames on a rigid analytical basis. In highway bridges, for example, a spandrel-braced arch is freqently used. In such a case columns are rigidly connected to the arch ribs and to the superstructure, and therefore the design should be made as a rigidly connected frame. The designing of trestles and viaducts as a frame will secure safety and at the same time obtain the best proportioning parts.

Box culverts and the box type of construction for subways give sections which are examples of the rigidly connected frame and which may not be rationally designed without a sufficient knowledge of rigid frames.

In water tanks and reservoirs of a rectangular or a polygonal form, the unknown negative bending moment due to a rigid connection of wall to wall or base to wall will exist at each corner. These moments are modified by the relative thickness of walls and the other dimensions of the structure. A knowledge of the rigid frame will suggest the proper method of solution.

It can thus be seen that most monolithic construction falls within the field of the rigid frame. A study of the rigid frame will assist in developing judgment for use in the design of such construction.

In building and structural design, insufficient attention is often given to the bending of columns caused by the rigidity of connections. The bending moment for a beam is frequently taken as an assumed fraction of Pl (where P is the load and l is the span) while bending moments at the ends and in the columns are disregarded entirely, thus leaving the structure inadequate or making one part stronger at the expense of the other.

The reinforced concrete frame is advantageous in that material can be saved, and a much better result obtained from the theoretical and structural point of view. In ordinary concrete building construction the element of rigidity is usually not fully taken advantage of. With the concrete frame construction, however, the rigidity of the connection of the members may be used. The rigid frame is capable of exact design, and therefore the economical distribution of materials can be realized.

One reason why some engineers hesitate to use concrete frames extensively is that they hardly believe in the continuity of the parts of the structure and doubt the effect of the rigidity of the connection. The question is also naturally raised if the formulas deduced from the elastic work of deformation of a non-homogeneous material like reinforced concrete will hold good for such composite members with fair agreement; furthermore the secondary stresses may act to modify the results. Under actual conditions, as is well known, in fundamental assumptions which underlie the static considerations can seldom be more than partially fulfilled even under carefully prepared specifications and well executed designs. These things must be considered before coming to a conclusion as to the reliability of rigidly connected reinforced concrete frames. It is evident that reinforced concrete frames will be reliable if there is perfect continuity or complete rigidity of joint, close agreement between theory and experiment, and a small effect of stresses of a secondary character. It is not known that an experimental study of this subject has before been made. It may be expected then that careful experiments and investigation will give information which will help to settle these questions.

In the bulletin formulas for several types of statically indeterminate structures which have been deduced by the use of the principle of least work are given. For vertical load the following cases have been analyzed: (1) single story, single span; (2) single story, three spans; (3) trestle bent with tie single span; (4) building frame with several stories and several spans; and (5) bridge trestle. For horizontal load the following cases have been analyzed: (1) single story, single span; (2) octagonal reservoir or tank; and (3) rectangular reservoir or tank.

In order to put to practical test the reliability of these formulas for reinforced concrete structures, eight test frames designed according to the formulas found by the analyses were made, and the deformations produced in the various parts of the members by the series of test loads were measured. In the design of the frames requiremnts not touched upon by the analyses referred to were provided for in a practical way. The analyses and the results of the tests have been subjected to critical study and discussion. The specimens were made in November and December, 1913, and January, 1914, and were tested in January, February, and March, 1914. In making these tests the purpose was to obtain experimental information along the following lines which have a bearing on the design of rigidly connected reinforced concrete frames:

(1) The amount and the distribution of stresses in the reinforcement and in the concrete

(2) The continuity of the composing members of a frame

(3) The location of sections of critical stress

(4) The reliability of a reinforced concrete frame

(5) The applicability of the theoretical formulas in the design of frames.

Eight frames comprising five different types were selected for this series of tests. The cross section of the members varied from 8 by 8 in. to 8 by 17⅜ in. The figure shows a line diagram of the eight frames with positions of loads and dimensions. The letters A, B and C mark the points used for a comparison of the computed and observed stresses.

Conditions Considered in Comparing Test Results with Analysis.—The following conditions were considered in the comparison of tests with analysis:

(1) The quality of the concrete was not uniform over the cross-section of the member. The frames were made in a horizontal position on the floor of the laboratory, and the concrete on the rear side of the frame (the bottom side for the position in which the frame was made) seems to have been richer than that on the front side. The concrete on the rear side was stiffer and stronger than that on the front side and the distribution of steel trusses seem to have been modified by this fact. There was more stress in the steel at the rear side of the member than in the steel at the front side. It appears reasonable to take the average value of the ob-

served stresses in the part in question for the purpose of comparison.

(2) The steel stresses are greatly modified by the presence of tension in the concrete for the low loads. Therefore in comparing the computed stresses with the observed stresses, two cases must be considered, one in which the concrete is considered to take tension and the other in which the concrete is considered to be broken in tension.

(3) The cross-section of the test frames were designedly made larger in proportion to the span than would commonly be used in practice. In most of the test pieces, the column width occupied nearly one-seventh of the nominal span (distance center to center of the columns). In addition to this the corner at the juncture of the beam and the column was provided with a fillet. Under these conditions the bending moment at the center of the beam will be less than that calculated on the basis of the nominal span length—the difference being greater than that occurring with the dimensions found in practice. In the computations for the horizontal reactions the nominal span and height of the frame (distances center to center) were used. In finding the numerical values of the bending moment in the beam, and also of those in columns having fixed ends, the horizontal reactions computed as described previously were used, but when the equations involved further use of span lengths the nominal span length was replaced by the clear length of the span.

(4) The design of Frames 1 to 7 was such as to cause high stresses in columns and beams at about the same time. In Frame 8 the presence of the members of unloaded panels caused the moments in the columns to be much smaller than in the loaded beam. The base also offered so much restraint as to give the column ends almost a fixed condition. Consequently loads which would cause high stresses in the beams would not produce cracks even in the intermediate columns although the moment there would be greater than in the outer columns. It will be seen then that for Frame 8 there are two cases to be considered in comparing the experimental results with the analyses, one in which tensile strength in the concrete is considered in all members and the other in which the beams and the intermediate columns are cracked on the tension side. The bending moment in the outside column is very small, and there is no chance for tension cracks. The moments in the intermediate columns and in the beams of the side spans are also small except at the extreme end, and only one crack apeared in this member. Therefore in the calculation of the moment of inertia of the cross-section for the second case it is not correct to neglect entirely the tensile strength of the concrete in these two members. A probable value for the moment of inertia of these members will be an average between that obtaind by using the full cross-section and a section which neglects the part outside the tension rods. This assumption was made in the numerical computation of the moments and stresses of Frame 8.

In making the computations of stress in the concrete of the frames a constant modulus of elasticity was used, that is, a straight line stress-deformation relation was assumed. The selection of a proper value of the modulus of elasticity was somewhat dependent upon a knowledge of the qualities of the concrete of the various frames and a comparison of the behavior of the frames with that of the corresponding control cylinders. Naturally the modulus of elasticity used was generally less than the initial modulus.

Experimental and Computed Values Show Fair Agreement.—Dr. Abe states that the tests seem to justify the following statements:

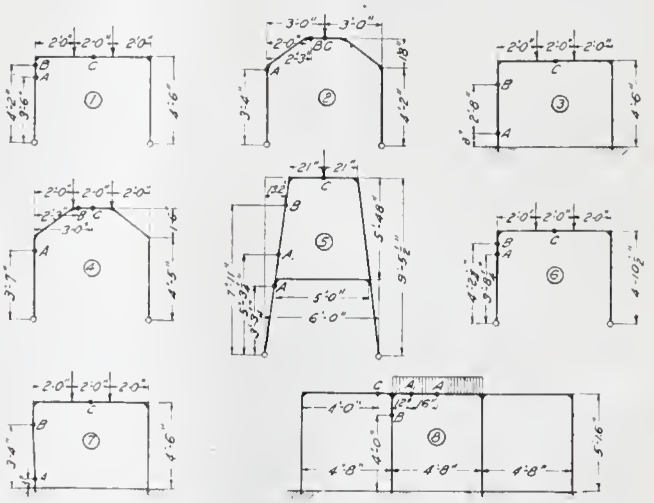
(1) The experimental and the computed values of steel stress at the center of the loaded top beam are in fair agreement for each kind of frame tested except in a few instances in which the load was comparatively low or extremely high.

(2) The experimental and the computed values of the steel stress in the columns are also in fair agreement, but the maximum difference between experimental and theoretical values is higher than in the beams, owing to the fact that the direct stress is not equally distributed over the cross-section of the column.

(3) The observed compressive stresses in the concrete at the low loads which developed a unit-stress up to about 800 lb. per square inch agree reasonably well with the computed values though in most of these cases the observed concrete stresses were somewhat higher than the computed stresses. In some instances the discrepancies ran up to 50 per cent, and for higher stresses the discrepancies were frequently even greater. Undoubtedly these differences are partly due to the fact that the modulus of elasticity used does not represent correctly the modulus of elasticity of the concrete in the frames. Other matters difficult of explanation probably cause further discrepancies.

Conclusions of Dr. Abe.—The author draws the following conclusions:

(1) Considering the errors involved in the measurement of the deformations and in the determination of the modulus of elasticity of the concrete, as well as those due to assumptions with reference to the distribution of stresses across the section and over the gage length, the results presented indicate a fair agreement between analyses and tests and justify the conclusion that the formulas given in the bulletin for statically indeterminate stresses as applied to reinforced concrete structures will give values for stresses in the members well within the limit of accuracy required in design



Test Frames, Showing Points Used for Comparison of Computed and Observed Stresses.

(2) The elastic action of the frames under external load and the manner of stress distribution along the members of the frame agree fairly well with the analyses given.

(3) The location of the point of inflection in the members of the frames under load agrees closely with the location found by analysis.

(4) If a frame is carefully designed and well reinforced, there need be no anxiety as to the rigidity of a joint. Effective continuity of members has been found in the tests.

(5) No sudden failure took place in the frames tested. The increase in the deflection was uniform, indicating as great reliability for reinforced concrete frames as for steel structures.

(6) The load at which the first fine crack appears near the juncture of members is increased by fixing the lower column ends of a frame. This is obviously due to the increase in horizontal thrust at the lower column end over that developed when the lower end is free to turn.

(7) At sharp inside corners, high compressive stresses were developed in the concrete due to so-called curved beam action and in several cases local failure occurred by the crushing of the concrete at these corners under high loads.

(8) A slight deviation of the axis of vertical members from a vertical line, that is to say, a slight "out-of-form" of the stress distribution in the frame.

(9) Owing to the existence of a horizontal thrust (which varies from $\frac{1}{8}$ P to $\frac{1}{18}$ P in most common cases of simple frames) at the ends of a vertical or inclined member, it is advisable to incline the member slightly toward the direction of the reaction at the end. Such an arrangement will greatly reduce the bending stress in the member. If this arrangement is not practicable, a slight increase in the top width of a vertical member and a slight decrease in its bottom width, brought about by inclining the inner surface and making the outer surface vertical will add materially to the rigidity of a frame without a proportional increase in the amount of material used.

(10) For a frame having an inclined column, it may be possible to select the form of frame in such a way that the column will take no bending stress throughout its length.

(11) Due attention should be paid to the rigid joint of a tie member to insure the stiff connection with a main member. A marked tendency to cause a sudden breaking of such a joint accompanied an increase of bending moment in a main member.

(12) The use of a footing rigidly connected to the lower end of a vertical member is advisable, for it will reduce the bending moment at the juncture of the vertical and inclined members. A frame having such a footing is solvable analytically, since it approaches the case half way between that of the hinged end and that of the fixed end of the vertical member, provided the foundation is sufficiently unyielding. A little consideration is needed to provide proper reinforcement at the juncture of the column and the footing.

(13) The formulas derived by analysis may be applied to a variety of forms of frames and are of wide applicability.

Dr. Abe's monograph is another indication of the valuable services which, during the past fifteen years, have been rendered to the engineering profession in the field of reinforced concrete under the direction of Professor Arthur N. Talbot.

Rental Charges for Construction Equipment

The largest and most successful general contractors are adopting a policy of returning all important standard plant and equipment no longer required on a particular piece of construction to a general or branch storehouse, where it is repaired and put into condition for the next job, and of charging a standard rental price for its use against each contract. The Associated General Contractors of America is now making an investigation of rental charges for the use of such equipment with a view to establishing a standard equipment rental schedule. It is readily apparent that such a schedule would be of great value in helping to standardize costs in making estimates. In the July monthly news letter of the association, two schedules of rental charges, submitted by two representative construction firms, members of the association, are printed. These schedules and the contract forms are as follows:

Rental and Other Charges for Contractor's Equipment.

Construction Equipment.—The contractor will supply all construction equipment of every description for the proper handling of the work. For such construction plant or parts thereof as the contractor may own or furnish, rental will be charged at the rates mentioned below, and such construction equipment will be carried on the contractor's regular payrolls for this work and as a part thereof at these rates, or as otherwise specified below for each and every working day, also for Sundays and holidays, if used. In the event of the Contractor's equipment being used for a longer period of time per day than the regular working day an additional pro rata charge of the scheduled rates will be made for such overtime as each item is used.

The duration for which rental will be charged, except as otherwise provided below, is from the time contractor's equipment is loaded on cars for shipment to the work, as shown by the shipping manifest, until contractor's equipment is loaded again for return to the contractor, unless other conditions are agreed to in writing, Sundays and holidays excepted unless used.

Charges for the use of such construction equipment as it is desirable or necessary for the contractor to rent from outside sources will be made in accordance with the bills rendered by the suppliers of such equipment, together with all expenses in connection therewith for which the contractor is liable.

Repairs.—Contractor's equipment will be shipped in good operative condition, and charges for ordinary replacement of parts or other repairs necessitated during the progress of the work will be billed at cost of such replacement or repairs. On rented equipment charges for repairs will be in accordance with the agreement with the owners of such equipment.

Small Tools—Under this item are to be included all tools used, not scheduled below, including carts, wheelbarrows, shovels, picks, bars, wrenches, axes, drills, wire cables, ropes, rubber boots and similar items, and a charge for the use of same will be made as a lump-sum equal to two and one-half per cent (2½%) of the total amounts of the Contractor's payrolls for this work.

Teams—All teams used for and on this work will be charged for and carried on the payrolls at the prevailing local rates.

Transportation—Trucking, freight, express and all other such items as may be incurred for the delivery to the work and reshipment back to the Contractor of all Contractor's equipment and all labor and expense in connection therewith, and for the putting together, setting in place and moving, together with the dismantling, moving and reloading of all [illegible] equipment for this work will be billed in addition to the other charges mentioned above.

RENTAL CHARGES PER DAY FOR EQUIPMENT AS MENTIONED IN THIS CONTRACT

Equipment.	Eastern Construction Co.	Central Western Constr'n Co.
Adding and listing machines, Burroughs No. 301	$ [illegible]	$ [illegible]
Adding and listing machines, special types at	Special prices	
Automobile trucks and trailers	Special prices	
Back filler, power driven	7.50	6.[illegible]
Boiler and 3-drum engine	6.00	4.[illegible]
Boiler and 2-drum engine	5.00	4.50
Boiler and 1-drum engine	3.50	2.50
Boiler only, 30 hp. and smaller	2.50	1.[illegible]
Boiler only, 30 to 80 hp.	4.00	2.50
Boring machine, pneumatic	.75	.79
Boring machine, electric	.75	.60
Bucket, tipple and bottom dump	10	[illegible]
Bucket, orange peel, ¾ and 1 yd.	6.00	2.00
Bucket, orange peel, less than ¾ yd	3.50	1.[illegible]
Bucket, clamshell, 1 yd.	3.50	1.[illegible]
Cars, skip, 1½ yd.	5	.25
Cars, skip, 3 yd.	1.00	[illegible]
Cars, steel, 1 yd. and smaller	25	[illegible]
Cars, wooden, 4 yd.	.50	[illegible]
Cars, wooden, 6 yd.	1.50	.75
Cars, wooden, 12 yd. and larger	Special prices	
Cars, 1 yd. hopper, radial gate	50	.25
Compressor, large sizes	Special prices	
Compressor, 10x10, with steam engine	4.00	2.25
Compressor, 8x8, belt driven engine	2.00	1.25
Compressor, small, with gasoline engine on wheels	5.00	[illegible]
Compressor, large, with gasoline engine on wheels	10.00	[illegible]
Compressor, Westinghouse, 9½ in., single action	1.50	1.00
Compressor, Westinghouse, cross compound	3.00	2.00
Counterweight drum	1.00	[illegible]
Crusher only	4.00	2.50
Crusher with elevator and screen	5.00	4.00
Cutter, bar portable, with motor	4.00	2.75
Derrick, 60 to 85 ft., wooden	3.50	2.[illegible]
Derrick, 30 to 59 ft., wooden	2.50	1.50
Derrick, less than 30 ft.	1.50	1.00
Derrick breast	10	[illegible]
Derrick, circle swing	40	[illegible]
Derrick, steel, 80 to 90 ft.	6.00	4.00
Drill rig, auto traction	15.00	7.50
Drill, small air	.75	.50
Drill, steam	1.50	1.25
Drill, Duntley electric track drill, 550-volt	3.00	2.[illegible]
Elevator, platform or bucket	50	[illegible]
Elevator, with bins for concrete	75	[illegible]
Engine, skeleton, 3-drum	4.00	3.00
Eninge, skeleton, 2-drum	3.00	2.50
Engine, skeleton, 1-drum	2.00	1.50
Engine, steam, horizontal, 11 to 40 hp.	2.50	2.00
Engine, steam, upright, to 10 hp.	1.00	.67
Engine, gasoline, to 8 hp.	1.00	.67
Engine, gasoline, 10 hp.	2.00	1.00
Engine, derrick swinging	1.00	.75
Engine, 2-drum, with electric motor	7.00	4.0[illegible]
Excavator, Keystone No. 3	30.00	15.[illegible]
Ford automobiles and light 4-cylinder cars	5.00	[illegible]
Hammers, riveting	50	.50
Hood elevating machine, hand power	2.00	.75
Leveling instrument, engineers'	.50	.30
Locomotive, 36 in. Dinkey	7.50	5.00
Locomotive, standard gage, saddle tank	Special prices	
Mixers, with boiler and side loader	7.00	5.0[illegible]
Mixers, with boiler	5.00	3.50
Mixers, with electric motor, to 1 yd.	7.00	5.00
Mixers, without boiler, less than 1 yd.	3.50	2.[illegible]
Mixers, without boiler, 1 yd. and larger	5.00	3.50
Mixers, with gasoline engine, 11 to 15 ft. capacity	4.00	3.00
Mixers, with gasoline engine, less than 11 ft	2.50	2.0[illegible]
Motorcycle	2.00	1.00
Motors, 2 hp.	.30	.20
Motors, 5 hp.	.75	.40
Motors, 10 hp.	1.00	.70
Motors, 25 hp.	2.00	1.50
Motors, 50 hp.	4.00	3.[illegible]
Motors, larger sizes, per hp., per month	[illegible]	2.[illegible]
Pile hammers, steam, up to 2,500 lb.	4.50	3.75
Pile hammers, steam, larger than 2,500 lb.	7.00	5.50
Pumps, centrifugal, 10 in., belt driven	5.00	2.50
Pumps, centrifugal, 10 in. with motor attachment	7.00	4.[illegible]
Pumps, centrifugal, 8 in., steam connected	4.00	3.00
Pumps, centrifugal, 6 in., steam connected	3.00	2.25
Pumps, centrifugal, 4 in., steam connected	2.00	1.50
Pumps, duplex and triplex, to 3 in.	1.00	.70
Pumps, triplex and belt drive	50	.50
Pumps, Pulsometer, to 4 in.	1.00	.60
Pumps, Pulsometer, 4½ in. and larger	2.00	1.00
Pumps, with gasoline engine	2.50	1.00
Pumps, diaphragm	50	.30
Pumps, diaphragm, with gasoline engine	1.50	1.00
Rail, per ton	12	.08
Roller, horse	1.50	1.00
Safe Cabinets, with fillers	50	.30
Saw benches, plain	5[illegible]	.70
Saw benches, plain, with motor or gas engine attached	1.00	1.[illegible]
Saw table, railway cut off, no power	2.50	2.[illegible]
Saw, automatic feed, no power	1.00	1.0[illegible]
Saw, swing cut off, no power	50	.50
Saw, Elliot wood worker with motor	2.50	2.50
Saw, band, for iron, no power	7.5[illegible]	7.50
Scale boxes	50	.50
Scraper, wheel, 1 yd	50	.50
Sprinkling cart	2.00	1.50
Steam roller	10.00	10.00
Steam shovels, revolving, traction	30.00	15.00
Tamps, compressed air, for track	.75	.75
Transit	1.00	.50
Trench diggers, to 24 in. width	30.00	15.00
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The Stability of Reinforced Concrete Retaining Walls*

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The main difficulty in designing reinforced concrete retaining walls is the determination of the base and the assumption of the proper ratio between the length of the heel and that of the toe. Although all the authors who deal with this subject give a number of rules by which a retaining wall may be designed, it is left to the skill and perseverance of the designer to find, by tedious trial, the right dimensions of the base. As a rule, there are enough known quantities to render the problem—from a statical point of view—capable of but one solution. The difficulty lies in the rather unusual number of quantities which have to be taken into consideration, and the difficulty of solving the equations which express the relations between these quantities.

In this article a diagram is given by which the solution of the final equations is obtained graphically and which enables the designer to see at once the influence of one or several of these quantities upon the result. It therefore makes it possible to find easily the most economical dimensions of the base of the wall and to eliminate, in most cases, any arbitrary assumptions of the ratio between heel and toe.

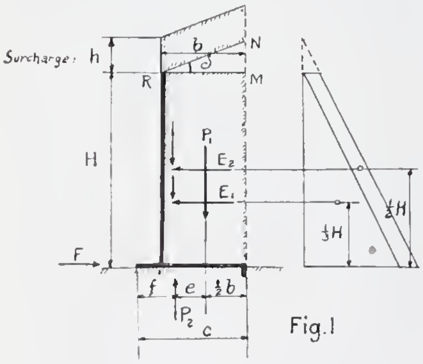

Fig. 1

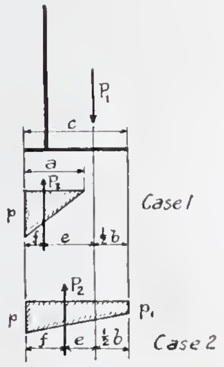

Fig. 2

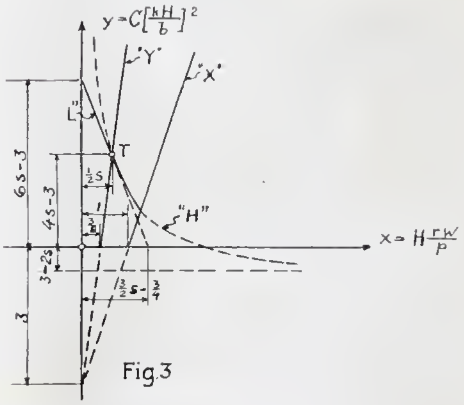

Fig. 3

Upon examination of the diagram it will be seen how important, for instance, is the influence of the max. allowable soil pressure on a minimum width of base. Even prominent authorities (see Turneaure and Maurer: Principles of Reinforced Concrete Construction, 1913) have entirely neglected this fact, and have made the width of the base only a function of the height of the wall and the quality of the backfill. In an example of this article it will be shown that, where Turneaure and Maurer recommend a minimum base of one-half of the height of the wall, a base of only 0.475H will furnish a retaining wall of the same stability.

Let E_1 and E_2 be the earth pressures, F the friction on the base, P_1 the resultant of the vertical loads and P_2 the resultant soil pressure, then we have the three equations for equilibrium:

$$E_1 + E_2 - F = 0 \quad \ldots\ldots (1)$$

$$P_1 - P_2 = 0 \quad \ldots\ldots (2)$$

$$\tfrac{1}{3}E_1H + \tfrac{1}{2}E_2H - P_1e = 0 \quad \ldots\ldots (3)$$

The first equation has no influence on b or c for with high earth pressure a key in the base will develop the necessary amount of horizontal reaction. Neglecting the vertical component of the earth pressure and the weight of the backfill RMN we get:

$$E_1 = \tfrac{1}{2}H^2wC.$$

$$E_2 = HhwC$$

$$P_1 = b(H + h)w$$

w being the weight of the backfill, and according to Rankine's theory

$$C = \cos^2\delta \frac{\cos\delta - \sqrt{\cos^2\delta - \cos^2\phi}}{\cos\delta + \sqrt{\cos^2\delta - \cos^2\phi}}$$

ϕ is the angle of internal friction of the fill.

Substituting: r for $1 + h/H$,

and k^2 for $\dfrac{1 + 3h/H}{1 + h/H}$

equations (2) and (3) become:

$$P^2 = brHw \quad \ldots\ldots (4)$$

$$\tfrac{1}{6}Ck^2H^2 = be \quad \ldots\ldots (5)$$

With regard to the location of P_2 there are the following four cases possible:

1............$0 < f < c/3$.
2............$c/3 < f < c/2$.
3............$f = c/3$.
4............$f = c/2$.

It is obvious that $f > c/2$ will furnish unecomonical results.

Equations (4) and (5) for case 1 will be:

$$\tfrac{1}{2}pa = brHw \quad \ldots\ldots (6)$$

$$\tfrac{1}{6}CH^2k^2 = b(c - b/2 - a/3) \quad \ldots\ldots (7)$$

Solving the first equation for a, and substituting in the second equation, we get:

$$C(kH/b)^2 = 6s - 4H\,wr/p - 3 \quad \ldots\ldots (8)$$

where $s = c/b$.

Equations (4) and (5) for case 2 will be:

$$bwrH = c/2\,(p + p_1) \quad \ldots\ldots (9)$$

$$\tfrac{1}{6}CH^2k^2 = b\left(c - \frac{b}{2} - \frac{c}{3} \times \frac{p + 2p_1}{p + p_1}\right) \quad \ldots\ldots (10)$$

Solving the first equation for p_1, and substituting this value in the second equation we get:

$$C[kH/b]^2 = s^2\,p/Hwr + 2s - 3 \quad \ldots\ldots (11)$$

Assuming a system of coordinate axes as indicated in Fig. 3, equations (8) and (11) can be written in the following form:

$$y = 6s - 4x - 3 \quad \ldots\ldots (12)$$

$$y = s^2/x + 2s - 3 \quad \ldots\ldots (13)$$

Equations (12) and (13) represent a straight line and a hyperbola respectively ("L" and "H" in Fig. 3), the first being the tangent of the latter. In the diagram ten such curves have been drawn according to values of s between 1 and 2.

Equations (4) and (5) for case 3:

$$\tfrac{1}{2}pc = brHw \quad \ldots\ldots (14)$$

$$\tfrac{1}{6}CH^2k^2 = b(c - b/2 - c/3) \quad \ldots\ldots (15)$$

Substituting the value for c of the first equation in the second equation we get:

$$C[kH/b]^2 = 8H\,rw/p - 3 \quad \ldots\ldots (16)$$

or

$$y = 8x - 3 \quad \ldots\ldots (17)$$

This represents a straight line "Y" in Fig. 3 and includes all the tangent points T of the hyperbolas "H." A similar line can be derived for case 4.

With $p_1 = p$ in (9) and (10) we get:

$$pc = brHw \quad \ldots\ldots (18)$$

$$\tfrac{1}{6}CH^2k^2 = \tfrac{1}{2}b\,(c - b) \quad \ldots\ldots (19)$$

and with similar substitutions as before:

$$C[kH/b]^2 = 3(Hr\,w/p - 1) \quad \ldots\ldots (20)$$

or

$$y = 3x - 3 \quad \ldots\ldots (21)$$

which represents the straight line "X" in Fig. 3.

It is obvious that the hyperbolas "H" are of use only between the lines "X" and "Y," and the straight lines "L" only to the left of "Y."

In equations (8) and (11) representing case 1 and 2 the following 8 quantities are used: C, H, k, r, w, p, b and s, the first 6 of which are usually known. Assuming an arbitrary value for b, equations (8) or (11) will furnish the unknown s.

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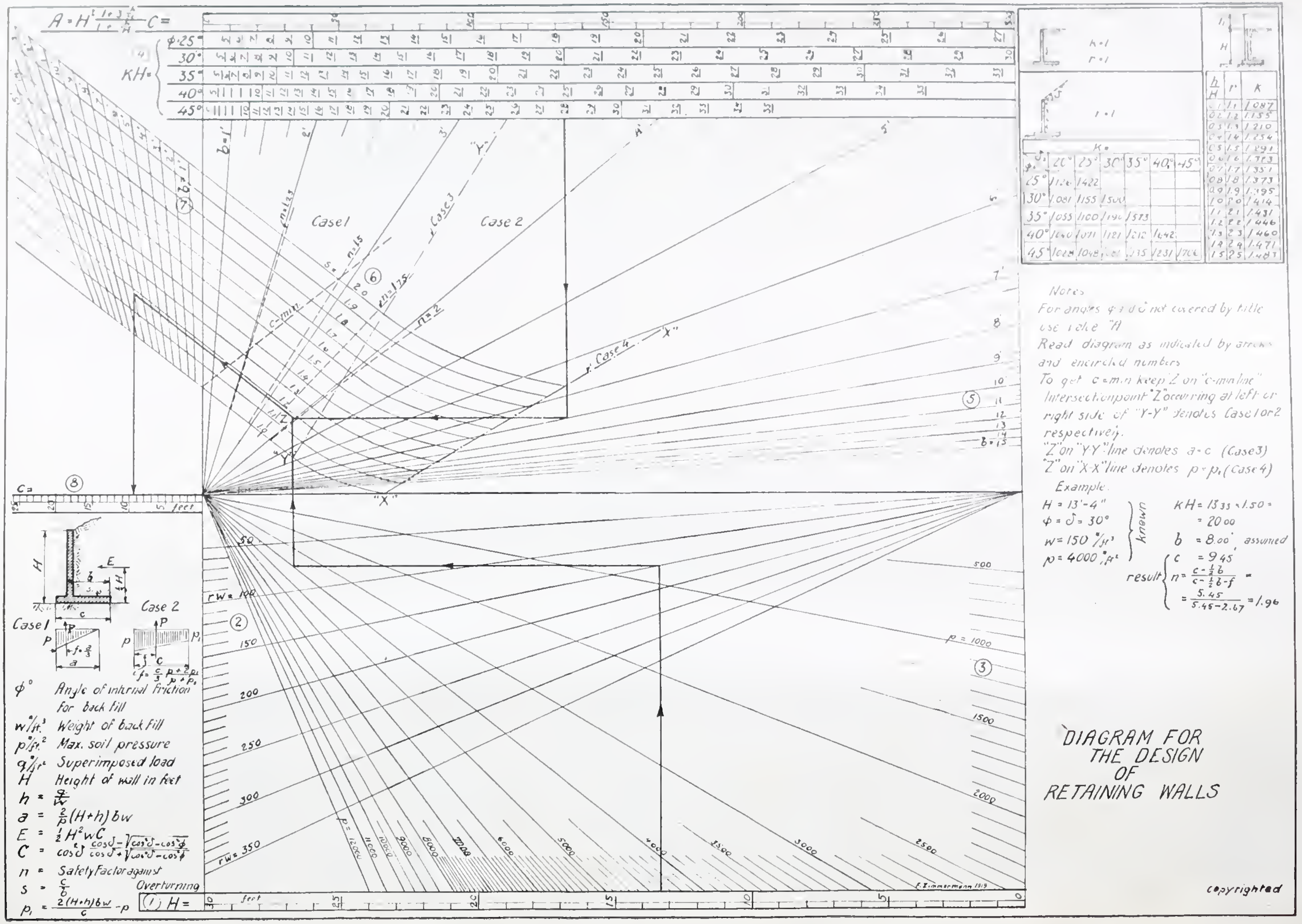

$\phi°$ Angle of internal friction for back fill
w #/ft.³ Weight of back fill
p #/ft.² Max. soil pressure
q #/ft.² Superimposed load
H Height of wall in feet
$h = \frac{q}{w}$
$a = \frac{2}{p}(H+h)bw$
$E = \frac{1}{2}H^2wC$
$C = \cos^2\delta\,\frac{\cos\delta - \sqrt{\cos^2\delta - \cos^2\phi}}{\cos\delta + \sqrt{\cos^2\delta - \cos^2\phi}}$
n = Safety Factor against Overturning
$s = \frac{c}{b}$
$p_1 = \frac{2(H+h)bw}{c} - p$

K =						
φ \ δ	20°	25°	30°	35°	40°	45°
25°	1.126	1.422				
30°	1.081	1.155	1.500			
35°	1.055	1.100	1.190	1.573		
40°	1.040	1.071	1.121	1.212	1.642	
45°	1.028	1.048	[illegible]	1.135	1.231	1.700

$\frac{h}{H}$	r	K
0.1	1.1	1.087
0.2	1.2	1.155
0.3	1.3	1.210
0.4	1.4	1.254
0.5	1.5	1.291
0.6	1.6	1.323
0.7	1.7	1.351
0.8	1.8	1.373
0.9	1.9	1.395
1.0	2.0	1.414
1.1	2.1	1.431
1.2	2.2	1.446
1.3	2.3	1.460
1.4	2.4	1.471
1.5	2.5	1.481

Notes

For angles φ and δ not covered by table use table "A"

Read diagram as indicated by arrows and encircled numbers

To get c = min keep Z on "c-min line"

Intersectionpoint "Z" occurring at left or right side of "Y-Y" denotes Case 1 or 2 respectively.

"Z" on "Y-Y" line denotes a = c (Case 3)

"Z" on "X-X" line denotes $p = p_1$ (Case 4)

Example.

$H = 13'-4''$
$\phi = \delta = 30°$
$w = 150$ #/ft.³
$p = 4000$ #/ft.²
known

$KH = 13.33 \times 1.50 = 20.00$
$b = 8.00'$ assumed

result
$c = 9.45'$
$n = \frac{c - \frac{1}{2}b}{c - \frac{1}{2}b - f} = \frac{5.45}{5.45 - 2.67} = 1.96$

DIAGRAM FOR THE DESIGN OF RETAINING WALLS

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For case 3 and 4 no such arbitrary value for b can be assumed, as the unknown quantities c and b are determined by equations (14), (15) or (18), (19). In case 1 and 2 the value b may be assumed so as to give a certain safety factor against overturning, n, or to make $c = \text{min.}$

The safcty factor against overturning is:

$$n = \frac{P_1\,(c - b/2)}{P_1\,(c - b/2 - f)} = \frac{2s - 1}{2s - 1 - 2f/b} \text{ (see Fig. 2)} \ldots (22)$$

or $$s(1 - 1/n) - \tfrac{1}{2}(1 - 1/n) = f/b \ldots (23)$$

for case 1: $f = a/3 = \tfrac{2}{3} bH\,rw/p = \tfrac{2}{3} bx$ (see eq. (6)).

$$s(1 - 1/n) - \tfrac{1}{2}(1 - 1/n) = \tfrac{2}{3} x \ldots (24)$$

for case 2: $f = c/3\,\dfrac{p + 2p_1}{p + p_1}$

Substituting p_1 of eq. (9):

$$f = \tfrac{2}{3} c - p\,\frac{c^2}{6bwHr} = \tfrac{2}{3} sb - \frac{s^2 b}{6x}$$

$$s(1 - 1/n) - \tfrac{1}{2}(1 - 1/n) = \tfrac{2}{3} s - \tfrac{1}{6} s^2/x \ldots (25)$$

Assuming $n = 2$ and eliminating s from eqs. (24), (12), and (25), (13), respectively, we get:

$$y = 4x \ldots (26)$$

and $$(\sqrt{x^2 + xy + 3x} - \sqrt{\tfrac{1}{4} x^2 + 3/2\, x})^2 = 9/4\, x^2 \ldots (27)$$

which are the equations of the $n = 2$ line of the diagram. Similar equations can be obtained for $n = 1.75$, and so on.

In order to make c a min. eqs. (6) and (7) have to be solved for c:

$$c = 1/6b\,CH^2k^2 + b(\tfrac{1}{2} + \tfrac{2}{3} x) \ldots (28)$$

for $c = \text{min.}$ there is:

$$\partial c/\partial b = 0 = -1/6b^2\,CH^2k^2 - \tfrac{1}{2} + \tfrac{2}{3} x.$$

$$b^2 = \frac{CH^2k^2}{3 + 4x} \ldots (29)$$

or $$y = 3 + 4x \ldots (30)$$

which represents the equation of the c-min. line of the diagram for case 1. Proceeding in a similar manner an equation can be derived for case 2. Eliminating p_1 from equations (9) and (10) and solving for c:

$$c = -bx \pm \sqrt{b^2 x\,(x + 3) + CxH^2k^2} \ldots (31)$$

making $\partial c/\partial b = 0$ we get:

$$y = 3 + 9/x \ldots (32)$$

As this condition can bc fulfilled only for values of s much greater than 2 the values c and b obtained through eq. (32) will be of little use. But it shows clearly that for such cases the greatest practical value for s will give the smallest base.

An interesting relation can be obtained by putting eq. (28) in the following form:

$$\tfrac{1}{6} CH^2k^2 = b^2\,(c/b - \tfrac{1}{2} - \tfrac{2}{3} x)$$

and substituting the value for b^2 from eq. (29):

$$c = b + 4/3\,bx$$

as $$x = H\,rw/p = a/2b$$

we get: $$c = b + \tfrac{2}{3} a \ldots (33)$$

which indicates that for the case $a \leqq c$ the base will be a minimum, when the resultant intersects the base at the center of the toe.

It should be well to understand that this result is based on the assumption that p has a constant value and represents a maximum allowable soil pressure. Some prominent authors have derived a minimum $c = 3/2b$ based on the assumption that $a = c$, corresponding to case 3 of this article. The reason for this assumption is not quite clear as it necessitates a variable p. A minimum c on that basis can not furnish any useful values as it makes p a function of c minimum instead of c being a function of maximum p.

If, for instance, a retaining wall be designed for $H = 20$ ft., $\phi = 30°$, $\delta = 0$, $w = 100$ lb., and a soil standing a maximum pressure of 4,000 lb. per square foot we get, according to those authors $b = 6.70$ ft., $c - \text{min.} = 10{,}000$ ft. and a soil pressure of only 2,690 lb. per square foot, with $n = 2$. In order to make use of the full value of the soil, keeping the same safety factor of 2, b has to be 8.2 ft. and c only 9.51 ft. This example shows clearly how misleading the so-called minimum is when an economical design is wanted.

In the diagram such additions have been made so as to avoid computing the values $x = Hrw/p$ and $Y = C(Hk/b)^2$. At the bottom there is a scale for the values of H. Intersecting at first with the rw and then with the p—line the value Hrw/p is obtained on the x—axis. At the top of the diagram scales are laid out for CH^2k^2, corresponding to values ϕ from 25° to 45°. The coefficients $r = 1 + h/H$ and

$$k = \sqrt{\frac{1 + 3\frac{h}{H}}{1 + \frac{h}{H}}}$$

can be taken from an accompanying table on the diagram. As C is computed for $\delta = 0$ the coefficient k for $\delta > 0$ and $h = 0$ will be

$$\frac{\cos\delta}{\tan\left(45° - \frac{\phi}{2}\right)} \sqrt{\frac{1 - \sqrt{1 - \left(\frac{\cos\phi}{\cos\delta}\right)^2}}{1 + \sqrt{1 - \left(\frac{\cos\phi}{\cos\delta}\right)^2}}}$$

This value can also be taken from the accompanying table. The intersection with the b—line furnishes the value $C(Hk/b)^2$ on the y—axis. The intersection Z of this horizontal line and the previously determined vertical line indicates the value of s.

The location of Z may be given by the assumption of a certain safety factor n or by the c—minimum line as the intersection of that line and the ordinate y; then, of course, b will be the result. If b and the location of Z are given p can be determined in a similar manner.

In reading the diagrem care should be taken to use the different scales in the right order. This order is indicated by a heavy line in the diagram. The arrows may be reversed according to the quantity that is to be determined. If, for instance, p is unknown all the arrows have to point towards the intersection point on the p—line.

The following examples may serve to illustrate the use of the diagram:

Example 1: Find the dimensions for the base of a retaining wall with the height, $H = 15$ ft., the backfill having a horizontal surface and no surcharge ($\delta = 0$, $h = 0$), its weight w being 100 lb. per cubic feet with an angle of internal friction, $\phi = 35°$. The soil pressure p at toe shall not exceed 2,500 lb. per square foot, and the safety factor against overturning, n, shall be 2. The table of coefficients k and r gives for this case $k = 1$ and $r = 1$. Start at the bottom of the diagram from a point indicating $H = 15$ on scale (1). Draw a vertical line and intersect with the line $w = 100$, indicated on scale (2); from there a horizontal line to the intersection with 2,500 on scale (3); then a vertical line intersecting with the line $n = 2$ in the upper part of the diagram, giving the point Z and indicating $s = 1.3$ on scale (6). Find the point $kH = 15$ on scale (4) for $\phi = 35°$, draw from there a vertical line until it intersects with a horizontal line through Z, giving $b = 5.0$ ft. on scale (5). To obtain c follow the direction of the s—lines, intersect with $b = 5.0$ on scale (7) and get $c = 6.5$ ft. on scale (8). As Z occurs at the left side of "Y—Y" the resultant of the earth pressure and the vertical intersects the base according to case 1 at a point

$$\tfrac{1}{3} a = \tfrac{2}{3} \times \frac{15 \times 5 \times 100}{2.500} = 2.0 \text{ ft. from the edge of the toe.}$$

Example 2: What is the maximum surcharge and the soil pressure for the wall in Example 1, if n be reduced to 1.5? By means of scales (8) and (7) we obtain $s = 1.3$. Intersect this line with the line $n = 1.5$; from there draw a horizontal line and intersect with $b = 5.0$, then a vertical line giving $kH = 17.3$ on scale (4) for $\phi = 35°$; as $k = 17.3/15 = 1.153$, the table of coefficients gives $r = 1.2$ and $h/H = 0.2$ for the surcharge $q = 15 \times 0.2 \times 100 = 300$ lb. per square foot and $rw = 120$. To find the soil pressure draw a vertical line from $H = 15$ on scale (1) and intersect with $rw = 120$; from there a horizontal line which intersects the vertical through the previously determined point Z at $p = 4{,}720$ lb. per square feet.

Example 3: What is the smallest base for $H = 18$ ft., $\phi = 35°$, $\delta = 25°$, $w = 90$ lb., $p = 6{,}000$ lb.?

For this case r is equal 1 and $kH = 1.100 \times 19.8$. Draw lines in the order (1)— (2)— (3); intersect the minimum c—line, giving $s = 1.37$; with $kH = 19.8$ on scale (4), $b = 5.13$ on scale (5) and $c = 7.0$ on scales (7) and (8):

$$a = \frac{2 \times 90 \times 18 \times 5.13}{6{,}000} = 2.77'; \quad n = \frac{7.0 - \tfrac{1}{2}\,5.13}{7.0 - \tfrac{1}{2}\,5.13 - \tfrac{1}{3}\,2.77} = 1.26$$

Fatigue Tests of Nickel Steel and Chrome-Nickel Steel

Tests of nickel steel of about 3.3 per cent nickel content and of chrome-nickel steel with about 0.8 per cent chromium and 1.3 per cent nickel, made in the Materials Testing Laboratory of the University of Illinois, indicate that the results of a static tension test are not a reliable index of fatigue strength of the material under oft-repeated low stresses, and that high stress, short time fatigue tests do not give a reliable index of fatigue strength under oft-repeated low stresses. The test results indicate also that a heat treatment may raise the elastic strength of a steel without increasing its fatigue resistance under low stresses, and that perfection of surface finish is an important factor in determining fatigue resistance under oft-repeated low stresses. The tests were reported by H. F. Moore and Arthur G. Gehrig in a paper presented last month at the annual meeting of the American Society for Testing Materials. An abstract of the paper follows.

Tests were made of annealed material, of heat treated material and of specimens with polished surface.

The specimens of nickel steel were cut from unstressed portions of test plates furnished some years ago for a series of tests on nickel-steel riveted joints, and the material for these plates was carefully selected with a view to uniformity. The specimens of chrome-nickel steel were obtained from one bar of steel 1¾ in. in diameter, which was drawn hot under a hammer to ⅜ by ¾ in. in cross-section.

All specimens were first annealed, the nickel steel specimens from a temperature of 1320° F. (716° C.), and the chrome-nickel specimens from a temperature of 1425° F. (774° C.). Some specimens were tested annealed; other specimens were first annealed as above and then were given one of two different heat treatments, known as heat treatment "H" and heat treatment "K" respectively. In heat treatment "H" the metal is heated to a temperature of 1550° F. (843° C.), quenched in fish oil at room temperature, reheated to 900° F. (482° C.), and cooled slowly in charcoal. In heat treatment "K" the material is heated to 1525° F. (835° C.), quenched in fish oil, reheated to 1350° F. (832° C.), quenched in fish oil, reheated to 900° F. (482° C.), and cooled slowly in charcoal. For most of the specimens the surface was left in the condition resulting from the last heat treatment. In no case was there serious scaling. For some of the specimens the surface was polished. The direction of polishing was parallel to the longitudinal axis of the specimen. The polish used for certain nickel steel specimens consisted of four steps: (1) grinding on a coarse emery wheel, (2) grinding on an emery-filled buffer, (3) grinding on a buffer filled with crocus composition, and (4) grinding on a dry felt buffer. The polish used for certain chrome-nickel steel specimens involved three steps: (1) grinding on a coarse emery wheel, (2) grinding on a medium-grain emery wheel, and (3) grinding with a fine-grain oil-filled emery wheel. The second method gave a distinctly smoother polish than did the first method. Both polishes were good shop polishes; neither gave a smooth "flowed surface" such as is necessary for metallographic specimens.

Table I gives the results of the static tension tests of specimens of the materials tested, and Table II gives the results of the fatigue tests under repeated stress.

The test results indicate that static elastic strength (as indicated by the proportional limit or the "useful limit") is not a reliable index of fatigue-resisting strength under repeated stress. The specimens of chrome-nickel steel, both the annealed specimens and the heat-treated specimens, showed higher proportional limits and "useful limits" than did the corresponding specimens of nickel steel, but the nickel steel specimens gave longer endurance under repeated reversals of low fiber stress than did the corresponding specimens of chrome-nickel steel. For both nickel steel and chrome-nickel steel the heat treatment used raised the proportional limit, the "useful limit" and the tensile strength in a marked degree, but the heat treatments added but little to the fatigue resistance under repeated reversals of low stress.

A repeated stress test using very high stresses, with consequent small number of repetitions for failure, cannot be relied on to give an index of the fatigue-resisting pow[illegible] of a material under a large number of repetitions of small [illegible]

These test results should not, of course, be interpreted to mean that chrome-nickel steel is, in general, inferior in fatigue resistance to nickel steel. These tests give values for the two lots of steel tested, and it should be remembered that the original bar of chrome-nickel steel was worked down to small size under a forge shop hammer Injury to the structure of the material may have been done in that process.

The tests also indicate that a given heat treatment may give high elastic static strength to steel without proportionately increasing its resistance to fatigue under repeated stress. Here again a warning should be sounded against drawing from these tests the general conclusion that all heat treatment is ineffective in increasing the resistance of a material to fatigue under repeated stress. The test results apply only to the particular conditions of heat treatment actually given to the specimens tested, but they do furnish an illustration of heat treatment which raised static elastic strength without proportionately increasing resistance to fatigue under reversals of low stresses.

At first thought it would seem that any structural damage done by heat treatment or any structural imperfections present in metal would act to cause yielding under low stress and would give a low proportional limit in a static test of the material. It should be remembered, however, that in any determination of any kind of a statically determined "elastic limit" the elastic breakdown is indicated by the effect on the stretch over a considerable length of specimen. Considerable local damage could be done over a microscopic area without affecting the stretch over the length of the specimen to such an extent that extensometer readings would be appreciably affected. Such local damage over a microscopic area, whether caused by an internal flaw or external surface irregularily, may, however, start a pro-

TABLE I.—RESULTS OF STATIC TENSION TESTS

Each Value Is the Average of Two or More Test Results

	Nickel Steel				Chrome-Nickel Steel		
Tensile Properties	Annealed.	Heat Treatment "H".	Heat Treatment "K".	Heat Treatment "K" and Polished.	Annealed.	Annealed and polished.	Heat Treatment "H".
Proportional limit, lb. per sq. in.	15,500	99,500	88,200	83,500	33,800	39,700	138,000
Useful limit, lb. per sq. in.	19,900	107,700	91,500	89,000	36,000	42,200	144,800
Tensile strength, lb. per sq in.	80,800	130,700	107,100	115,200	86,600	91,600	169,000
Elongation in 2 in., pct..	32.0	19.5	23.5	21.5	23.7	21.0	11.0
Reduction of area, pct. .	58.5	58.0	61.0	59.0	49.7	47.0	13.5

TABLE II.—RESULTS OF REPEATED STRESS TESTS

Nominal Fiber Stresses Are Computed by Means of the Usual Flexure Formula.

Nickel Steel Specimens. Nominal Fiber Stress, lb. per sq. in.	Nickel Steel Specimens. Number of Reversals for Failure.	Chrome-Nickel Steel Specimens. Nominal Fiber Stress, lb. per sq. in.	Chrome-Nickel Steel Specimens. Number of Reversals for Failure.
ANNEALED SPECIMENS.			
69,000	10,900	50,800	13,400
58,000	35,600	43,200	113,500
42,000	166,600	35,700	148,300
37,000	1,164,000	33,300	190,400
28,000	1,540,000	31,700	230,600
		23,500	564,900
		17,800	3,935,100
HEAT TREATMENT "H"			
98,200	15,000	141,800	6,700
81,100	52,700	123,800	11,300
62,20	86,900	101,700	26,700
43 600	216,100	76,500	53,300
37,800	2,083,000	51,100	110,100
		29,600	353,500
		19,100	4,250,000'
Heat Treatment "K"		Annealed Specimens, Polished	
91,700	15,600	49,400	30,000
71,600	55,200	48,800	42,300
51,200	102,300	42,500	286,800
48,500	167,300	38,300	167,500
42,700	182,300	33,000	166,200
		28,900	597,300
		25,400	7,400,000
HEAT TREATMENT "K" Followed by Polishing			
96,000	12,100		
73,800	37,800		
47,000	228,200		
44,200	296,900		

Specimen not broken.

gressive fatigue failure of the material although it may not cause sufficient yielding of the specimen as a whole to affect appreciably an extensometer reading. An illustration of this local damage is furnished by the "snowflakes" sometimes found in steel, which do not seem to affect the static elastic strength of the steel, but are recognized as dangerous defects.

A high static elastic strength is of indirect advantage in materials subjected to repeated stress, even if it is not accompanied by increased endurance under repeated low stresses. Practically every machine member or structural part is subjected to occasional loads above the normal. If the material has a low static elastic strength such an overload may cause plastic action in parts of the member, and such plastic action (cold-working) tends to weaken the fatigue-resisting power of the material. If the material has a high elastic strength, while micro-flaws may be spreading slowly, yet under an occasional overload the spread of micro-flaws is not abnormally hastened by the formation of plastic material.

The tests indicate that perfection of surface finish is an appreciable factor in developing resistance to fatigue under repeated stress. The superiority in fatigue resistance of the polished specimens over unpolished specimens increases as lower test stresses are used. This superiority may be explained as follows: the nominal fiber stress in a machine or structural member, computed by the ordinary flexure formulas, does not take into account any localized stresses due to irregularity of surface or outline, yet both mathematical analysis and direct experiment indicate that over microscopic areas such localized stresses may be large.

The nominal fiber stress in a test specimen gives a fairly reliable basis for comparative tests, but, in all probability, does not give an accurate measure of the magnitude of the maximum localized stress in the specimen. Surface irregularities, especially sharp grooves and scratches, may cause high localized stresses, and microscopic cracks may start at such grooves or scratches, and, gradually spreading, cause eventual failure. It cannot be definitely stated that any machine or structural member is absolutely safe from the possibility of such failure if stresses are repeated often enough. It has been shown that the endurance of a repeated stress test specimen is appreciably lowered when on its polished surface a needle scratch is made. Good surface finish free from tool marks, and generous fillets at corners, are vital factors in prolonging the life of machine parts subjected to repeated stress.

Fatigue failure under repeated stress is a progressive failure starting in nearly all cases from some defect or irregularity either of internal structure or external surface. Freedom from internal flaws and surface irregularities is far more important in members subjected to repeated stress than in members subjected to but few repetitions of load.

Training Courses in Safety for the Building Trades

Accidents are assuming a very important bearing on the cost of building operations, as the states are enforcing workmen's compensation laws. Compensation or liability insurance is adding 3 ct. to 25 ct. per hour to the wages paid. In fact the average of the rate in one of our large cities on 36 building operations adds over 6 ct. per hour to the wages paid.

Although a considerable amount of attention has been devoted to accident prevention on railroads and in manufacturing industries, construction work has been almost entirely neglected in this respect. The Federal Board for Vocational Education, Washington, D. C., has just issued a most timely bulletin entitled "Training Courses in Safety and Hygiene in the Building Trades, Bulletin No. 31," which should be very helpful to those desirous of studying the hazards and methods of safeguarding against accidents in the building trades.

This bulletin is issued with the intention that it form the basis of definite instruction in safety and hygiene as applied to the building trades. It is intended primarily for use in vocational schools, but may be of use to employers who wish to promote safety methods and practices among their employes, and a fitting text book for those workmen who are desirous of improving their efficiency and anxious to avoid the hazards of their occupation.

Estimating on Building Contracts*

By CYRUS J. PARKER.

Member Portland General Building Contractors' Association.

There is no question in my mind but what we all make errors in estimates. As a matter of fact, when we get a job that is when we begin to wonder where we have made our error. I have heard fellows say: "How in the devil did I make my mistake?" They feel that contracts are let on errors, judging from the amount of money the contractors claim they have left when they complete their work. You will find in estimating that a man will have to make up a system of his own. I think that every man's method of contracting is peculiar to himself. It would be impossible for me to lay down such a system for another man, while I might take the system I have worked out and be very successful with it. You can buy trade accounts and hand books on estimating, and the majority of them I have read I would not give the snap of my finger for. The work is always different. You never have two pieces of work that cost the same.

I want to call your attention to a few methods of estimating. I happened to spend a few years in Louisiana, and I knew a contractor there who put in his estimates on the basis of cubing or squaring a foot in figuring on it. He is not in business any more. It also reminds me of a fellow who secured a set of plans that were quite bulky, and after looking them over handed them to his partner saying: "Take these damn things and go and weigh them and we will put it in." I know another contractor who claimed he could take a set of plans home in the evening and bring down a figure the next morning. He does it, and it is remarkable how close he comes to the value of it. But personally I would not want to risk that kind of a method. For my part I would rather take all of the quantities off in detail and base the estimate on some method of cost keeping that we might adopt. Each one would have to do it to suit himself. There is one advice I would like to give, however, and that is, if you keep a cost system, do not keep it in such a cumbersome manner that you can not handle it. I knew a contractor in Portland who did a large business but used a worn-out system, and he could not use it any further and went broke. To my mind, after you have a cost system worked out, you must have it in simple form so that you can combine it with good business judgment and the experience you have had in previous work, basing your estimate accordingly.

In estimating a plan it is necessary to find everything on it. If you do not, you may find after you have signed the contract a few lines of notes on the specifications that may cost you hundreds of dollars. I heard of a fellow who was constructing a building and noticed the initials "T R" in all the doors on the plan. After he had the building plastered the architect came around and asked him where he was going to put the transoms. His answer was: "There are no transoms on this building plan." The architect said, "Yes, there are. Let me have the plan and I will prove it to you." He proved it to him as he had "T R" on every door. After that experience the contractor always looked for all the TR's on the plan in every contract he secured.

I happened to be brought in on an arbitration case at one time where the contractors figured from a large plan ⅛-in. scale drawings. They had a large marker there, and from the elevation you might have struck there was a cornice around it that might have been of ordinary galvanized iron. The contractors presumably figured on some character of cornice on the outside. After the contract was signed and the building partially completed, the details showed a heavy cast iron cornice around the outside and cross beam incased in cast iron. The cast iron alone cost $1,100. The arbitration committee allowed the contractor for that. But it is evident that in figuring a plan we should not take the chance with ¼-in. scale drawing and put in a figure where we stand the chance of losing money as this man did. And even if he did get the money allowed him by the arbitration board there was trouble and dissatisfaction with the architect and all concerned. It is best to ask for details. Some contractors seem to think if you go to an architect and ask for details he will think you do not know your business. I think that is a part of their business; that is what they are getting paid for, furnishing details so a man can figure intelligently on a plan and not take a chance.

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*From a paper presented before Northwest Master Builders' Convention, Seattle.

Another thing! An architect frequently resorts to generalities in his specifications, such as "according to the satisfaction of the architect" and "in first class workmanlike manner" and "materials the best quality." Those are a few and there are many others that they put in specifications to which you have to give consideration in estimating. How is a contractor to know the specific tempermentalism of an architect when he wants it done to the satisfaction of the architect when he does not know what will satisfy the architect. So there should not be a general item of that kind in the specification.

There is not one contractor in a hundred who reads the clause, "materials of best quality" and realizes the interpretation that an architect intends to place on it. These must all be considered in estimating. If you do not do so, an architect, if he is inclined to be unscrupulous could make it very unpleasant for a contractor. And then comes the old clause saying: "This is intended to be a complete job, supposed to include everything necessary even though it is not particularly mentioned." Half of the plumbing might not be mentioned. But the part that is not mentioned must be put in, if you have that kind of a specification. You must consider all these items in compiling your estimates. They are just as important as taking off the quantities. In fact they are often more important.

There is another thing: In the past many contractors resorted to asking sub-bids on their work. Possibly at the present time many do this and possibly many may do so in the future. They act on the sub-bids they get and guess at the rest. A lot of them take sub-bids, and immediately after they have been awarded the contract, the contractors forget the subbidder who gave the bid and wasted time on it, and immediately start out to find more sub-bidders, after having taken the time of the original sub-bidder. Another method practiced by a contractor I once knew, whom I should say is out of business at this time, was to take sub-bids and revise them 5 per cent. saying he would beat the sub-bidder out of that much and that would make his regular bid 5 per cent lower than the rest of the general contractors.

It seems that it might be possible for contractors to get together and adopt some system of quantity surveying. We would not need to make it a guaranteed survey but could employ some man in the association. We would not be bound to use the figures of the survey, but it could be used as a check against the quantities we take off. It seems to me that we might work up something along this line that would be beneficial to contractors generally. It is not practical for contractors to take the immense risks taken by them in the past. Contracting is just as legitimate a business as any mercantile business carried on in a legitimate manner and I would favor the establishment of a method of opening up bids that would prevent any increase being made to them before they are put in. It is possible to select one out of the association and turn all the bids over to him and let him check them or audit them in a way, and if he finds an error let him refer it back to the original bidder. It would be a check on his estimate and at the same time it would be playing the cards on the table. We have passed the stage where we can play other than the square game. The old-time contractors who played the game of opening up figures and adding a certain amount of them have lost all the money they made on that method of figuring.

I believe the contractor should prepare himself so that he would take the entire quantities from the plan and not be tied up to a sub-contractor. I think, as a matter of fact, the contractor who plans to take all of the quantities off himself is in a better position to take the figures after he has the job than he is before the job is awarded.

Photographs Record Conditions Prior to Construction of Bridge.—In connection with the surveys for the Bloor St. viaduct at Toronto, Ont., an extensive set of photographs was taken in order to record conditions prior to construction in greater detail than was possible on drawings. The position of the camera for each picture was shown on a key plan by a small circle and the direction in which it was pointed was shown by an arrow. The number of the photograph was placed in the circle.

Bulking Effect of Moisture in Sand

The author of the above article in the Canadian Engineer of May 15, 1919, Capt. Llewellyn N. Edwards, again emphasizes the fact that laboratory methods of tests of concrete should take into account the field conditions of making concrete. Stone and sand are surface-dried and weighed in the laboratory but cannot obviously be so treated in the field.

In the measurement of sand, the custom is almost universally a volumetric one and very often a rough one, and barrow-measured quantities are notoriously inexact. But in addition to this there is the fact that moisture content of sand has very much to do with its bulk. Paradoxical as it may seem, the addition of a quantity of water, equal to 1 per cent. of the weight of a given quantity of dry sand, will serve to thoroughly coat the surfaces of the sand particles, a uniform distribution of the water being secured by working the sand with a trowel or other tool. This moisture has the rather remarkable effect of increasing the volume of sand by holding the sand particles somewhat rigidly in positions different from those they would readily assume when dry.

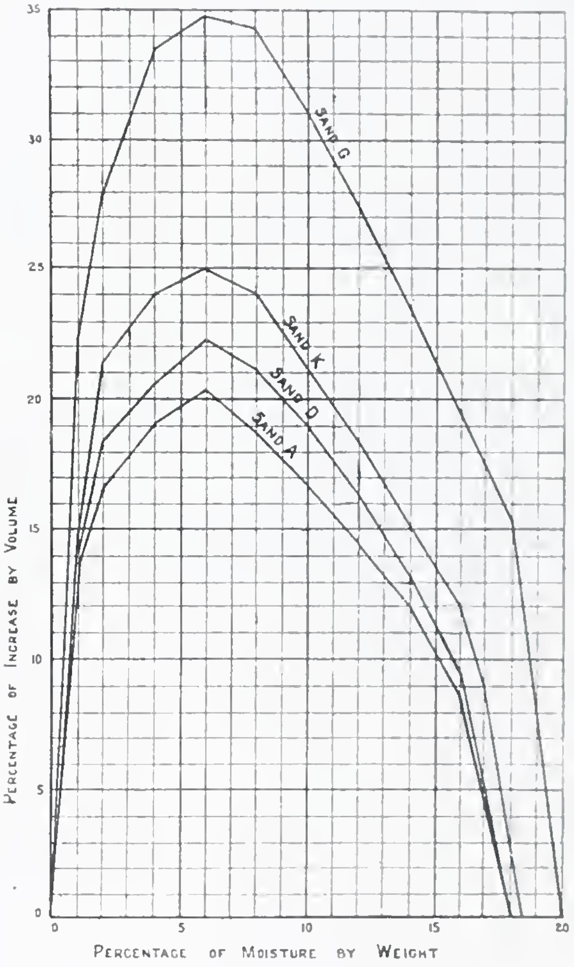

Fig. 1.—Relation of Moisture to Volumes of Sand.

A series of tests made for the purpose of securing definite information relative to the "bulking" effect of moisture in sands differing in their granulometric analyses, shows that the surface area of the sand particles is a direct function of the volume increases, produced by varying the quantities of water. In a portion of these tests the water content was varied in relation to the weight of the sand. Fig. 1 shows the volume increase curves derived from tests of four different sands. These curves are typical of those secured from the entire series of tests. In this connection it is of interest to note that when the water content has reached the "flooding" stage, the volume of the sand is the same as that originally occupied by it when thoroughly surface dried. Incidentally, Fig. 1 gives unquestionable proof of the reliability of the common practice of compacting sandy or other earths of rock origin by flooding them with water.

To illustrate what effect this "bulking" effect of wet sand has on a mix, Capt. Edwards gives the following:

Assume that a desired strength of concrete can be produced by the use of sand, thoroughly surface dry and mixed with cement and stone aggregate by volume measurement, one part cement, two parts sand, and four parts stone, 100 lb. of cement being considered as producing 1 cu. ft. of cement paste. Assume now that the sand, as used on the job, contains 6 per cent of moisture, and when shoveled into barrows will bulk up 23 per cent. From simple calculations it is found that the batch as used on the job will contain the following: 100 lb. cement, 1.54 cu. ft. sand, 4 cu. ft. stone.

Another condition may be mentioned here which indicates very clearly the "bulking" effect of moisture in sands. While the weights of sands vary with the character of the rock material from which they take their origin and also with their granulometric composition, yet, for any given sand, its weight per cubic foot when dry is greater than its weight when wet, provided, of course, that in each case the sand is shoveled into the measuring receptacle. This condition holds true, even when the wet sand is subjected to a moderate amount of of compacting.

An obvious method of avoiding the error in proportioning due to the "bulking effect" of wet sand would be to determine the approximate percentage of moisture and weigh the sand necessary for each batch. With all the improvements in modern machinery for mixing concrete there is still plenty of room for improvements in methods of mechanically proportioning the aggregates.

The Professional Man and Service

In his inaugural address, Henry K. Holsman, recently elected president of the Illinois Chapter of the American Institute of Architects, said, in part:

The profession of architecture imposes upon its members the same familiarity with the achievements of structural and social sciences. The architect must work in close co-operation and deep sympathy with other professions than his own. No individual can achieve in this profession by himself. Architecture does not depend upon the inspiration of genius but upon painstaking culture and talent and the mastery of the principles of the arts and sciences accumulated from all the ages, from men of all professional classes who have worked and thought along social, structural and esthetic lines. Architecture is a social phenomenon, not an individual prenomenon.

That our profession is the oldest and broadest and the last to come to consciousness is at once our opportunity and our responsibility. Being in sympathy with so many other professions it becomes our obligation to wake up and help to prepare for that day of full professional consciousness when men of all classes from the humblest trades unionist to the exalted statesman will ask and receive of the treasures laid up in professionalism. Class consciousness is the chief reason for the existence of any professional organization.

The world is fast becoming aware of the great value of the professional man. He is the man who stands ready to serve other men in their health and happiness, in their organizations and enterprises, in all their conceptions and achievements. What great commercial enterprise or what mighty utilization of forces would have been achieved by the so-called masters of industry had it not been for the professional man who patiently and systematicly worked it out, practically for the joy of achieving it? or what one of the great machines of finance or industry, or what government in war or peace could survive and develop, but for the continued devotion of the professional man? His services are not paid for in proportion to their value, and for some things he can not be bought. He is born of the people, seldom if ever of autocracy.

We are now awakening to the dawn of a new era. The age of kings and princes is past. The day of barons and aristocrats is waning, and the day of professionalism is at hand. Professionalism carries but one banner and written on that banner is but one word—Service. The law of its being is freedom restrained by culture, training and unbiased devotion to duty. The remuneration of its members is a known fee in proportion to the cost of preparation and the hazard of the undertaking, coupled with that distinctive mental exhilaration known to no other calling—the joy of solving a problem that makes life still more worth living.

Cements Producing Quick-Hardening Concrete*

In the course of the investigations which the Pittsburgh Branch of the Bureau of Standards has been conducting dealing with the various problems relating to Portland cement, there have been made a number of cements which are characterized by a very high early strength. This is developed when the cements are used either as mortars or concretes. These cements have been made in a manner differing in no wise from that used in the manufacture of Portland cement. However, the composition of the materials entering into their manufacture was decidedly different, limestone and calcined alumina having been used in some of the raw mixes, and in others the alumina was replaced in part by kaolin or bauxite in order to determine the effect of impurities on their general properties. While such materials have been the subject of research by others, especially Spackman, their property of developing very high early strengths is not generally known. It is believed that the data presented in this paper, especially that dealing with the concrete, are the first of their kind ever presented.

The data dealing with the aluminates are augmented by some obtained in making concrete from "Sorel cement" (a commercial product) which, as is generally known is light calcined magnesite gaged with magnesium chloride. It has been unofficially reported that during the recent war the enemy used a concrete made of such a cement for "setting up" their large guns. As it obtains the greater part of its strength within 24 hours and as this strength equals that obtained by a Portland cement at the end of two or three weeks, the possibility of using it becomes very attractive. The data presented were obtained in making a limited number of concretes, but it is believed that such data, in so far as they relate to concretes, have never before been presented.

Concrete Made with Sorel Cement.—At the present time this cement is used in rather large quantities for making a resilient flooring which is usually referred to as "composition flooring." When so used the aggregate is composed of asbestos fiber, sawdust, inert finely ground filler as sand and coloring matter. This flooring is widely used in a monolithic form in office buildings, passenger and subway cars and interior ship decks. Recently a mortar very similar in nature to the above, excepting the omission of the fibrous material, has been rather successfully used as a stucco.

The magnesia used in the present investigation was made from magnesite mined in California. It was a mixture of two shipments from two manufacturers of flooring. Both had given satisfactory results when used in flooring mixes. No data are at hand which would enable one familiar with Portland cement to form an idea of the relative strengths which these would develop in the usual small briquette or compression specimen. The small specimens made were of a flooring composition and as such were composed of 50 per cent magnesia, 12 per cent asbestos, 10 per cent sawdust, 22 per cent ground sand and 6 per cent iron oxide, all by weight. This mixture when gaged with 52 per cent of a solution of chloride having a gravity of 1.1885 (about 23° Baumé) gave the following strengths in pounds per square inch:

Specimen.		24 hours.	7 days.	28 days.	90 days.
A	Tension	531	841	1,087	1,034
	Compression	2,240	3,795	5,300	4,340
B	Tension	576	900	935	1,049
	Compression	2,900	4,240	5,300	5,370

In Table I is shown the strength of the concrete made from this mixed oxide and also the compressive strength developed by a Portland-cement concrete using the same proportions of the same aggregates. Notwithstanding the fact that the specific gravity of the magnesia is very close to that of Portland cement (3.08 for the magnesia and 3.12 for the cement), the volume occupied by the same weight of the two differs very materially. As the magnesia weighed but 51 lb. per cu. ft., the actual percentage by weight of the magnesia in any one concrete was decidedly less than the percentage of Portland cement. For this reason the 1:6 concrete was proportioned both by weight and by volume, when the magnesia was used as the cementing material. All specimens were stored in the air until broken. The gravel used was obtained from the Allegheny River and was screened between a ⅛-in. and 1½-in. screen. It contained an excessive amount of the finer sizes. The limestone was a rather soft stone screened between the ¼-in. and 1-in. screens. The "coarse sand" aggregate was sand from the Allegheny River screened between the ⅛-in. and ¼-in. screens.

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*Abstract of a paper presented at the 22nd annual meeting of the American Society for Testing Materials, held at Atlantic City, June 24-27.

As the information sought had to do alone with early strengths, specimens were made for breaking at 24 hours, 48 hours and 7 days in the case of those made with magnesia and 48 hours and 7 days when Portland cement was used.

The results show that the Sorel-cement concretes, with but two exceptions, have a strength at 48 hours greater than that obtained by the use of Portland cement in 7 days. However, it is also seen that there is in general but little increase in the strength of the former between the 48-hour period and the 7-day period. The results obtained at all periods from the Sorel-cement concrete proportioned by weight are generally higher than those obtained when the proportioning was done by volume, regardless of what the proportions were. This clearly shows that for such a light material the proportions should be decidedly different from those generally used with Portland cement. It would seem as if too much magnesia was used in the rich concretes and too little in the lean ones when the proportioning was carried out by volume.

Attention should be called to the difference in the manner in which the hardening of the two concretes takes place. In a Portland-cement concrete, the cement hardens by the action of the added water. During the process of hardening it is immersed in an atmosphere containing in a greater or less degree one of the essential elements of the process, that is, water either as a liquid or vapor. On the other hand, in the Sorel-cement concrete the hardening takes place as a result of the action of the chloride on the oxide. The chloride is always essential, but any deficiency, as for instance the use of a too dilute solution, or any marked excess, is injurious. Therefore, not only the ratios between the aggregate and the magnesia must be studied, but also the ratio between the chloride and the magnesia.

While the results do show the lack of proper proportioning of both the magnesia and the chloride, yet these poorly proportioned concretes show in 24 hours as high strengths as the more properly proportioned Portland-cement concretes show in seven days. Another point should be remembered in regard to these Sorel-cement concretes, that is, they cannot be frozen. Temperatures below freezing will retard the hardening to a degree, but the freezing point of the solution is so low that no care need be taken to prevent damage from low temperatures.

Concretes Made with Calcium-Aluminate Cements.—The calcium aluminates were all made in the experimental rotary kiln of the Bureau. The composition of these, the constitution arranged in order of the amounts present, and the temperatures of burning are given in Table II. The fineness and the time of setting* are given in Table III.

With the exception of cement No. 6, no particular difficulty was encountered in burning. On account of the composition of this cement, its position in the ternary system $CaO\text{-}Al_2O_3\text{-}SiO_2$ was such that it was located in a field having both a low burning temperature and also one in which the orthosilicate predominate. This combination always produces a material which fluxes at such a temperature that the silicate on cooling reverts to the γ form from the β form of the silicate. This reversion is manifested by the "dusting" of the clinker. It was possible to produce this particular cement only either in a decidedly underburned condition, or overburned to such a degree that it fell from the kiln in large, soft balls, which dusted on cooling unless quickly water quenched. The latter procedure of burning, without quenching, was used. Cement No. 1 was made from a very hard clinker, but the latter did not show any tendency toward dusting. The clinker of the other cements was of the porous character of normal Portland clinker. Those low in iron oxide were white to yellowish in color, none of them had the glistening black appearance of Portland clinker, the darkest being a dark reddish brown. The raw materials used were calcined alumina and limestone for cements Nos. 1, 2 and 8; in Nos. 3, 4 and 5 the same materials were used, but part of the alumina was replaced by a kaolin, thus reducing the alumina content of the mix but increasing the silica content. In No. 6 it was necessary to add some very finely ground flint, in order to secure the desired silica content, in addition to the kaolin, alumina and limestone, and iron oxide. In No. 7 bauxite, limestone and iron oxide were the raw materials.

Reference should be made to the work of Rankin and the author, for further information in regard to the general properties of the constituents of these cements. For this present paper dealing more particularly with concrete made from them, it is not desirable to give more in regard to their properties than their reaction with water. Those aluminates indicated in Table II, as being present in these cements, all react with water to form the hydrated form of $3CaO \cdot Al_2O_3$. Such a reaction requires the formation of hydrated alumina. The amount of the latter will depend upon the amount of the alumina in the cement, consequently

TABLE I—COMPARISON OF COMPRESSIVE STRENGTHS OF SOREL AND PORTLAND-CEMENT CONCRETES.

6 by 12-in. Cylinders. Strength in Pounds Per Square Inch.

Proportions by volume.	Percentage of cement by weight. Portland.	MgO.	24 hours. Portland.	MgO.	48 hours. Portland.	MgO.	7 days. Portland.	MgO.	Per cent H_2O in Portland-Cement Concrete.	Per cent $MgCl_2$ in Sorel-Cement Concrete.
					Gravel Aggregate.					
1:0.5:1.5	33.3	20.3	....	1,740	1,570	3,490	2,965	2,910	12.1	14.7
1:1.0:3.0	20.0	11.3	....	1,705	1,115	2,260	2,020	2,850	7.8	9.5
1:1.5:4.5	14.3	7.8	....	1,755	680	2,145	1,130	2,246	7.9	9.8
*1:1.5:4.5	....	14.3	....	2,880	....	3,315	....	2,72	....	12.1
					Limestone Aggregate.					
1: ⅔:1⅓	35.2	21.8	....	2,985	2,260	3,990	3,930	4,320	12.2	18.5
1:1⅓:2⅔	21.4	12.2	....	1,946	1,340	2,805	2,990	2,976	9.9	13.7
1:2 :4	15.4	8.5	....	1,935	655	2,330	1,755	2,480	9.5	12.8
*1:2 :4	....	15.4	....	3,270	....	4,020	....	4,320	..	13.7
					Coarse Sand Aggregate.					
1:0.5:1.5	34.0	20.8	....	2,060	1,715	2,570	3,270	2,735	13.2	20.0
1:1.0:3.0	20.6	11.6	....	1,910	545	2,225	1,635	2,130	11.4	16.0
1:1.5:4.5	14.7	8.0	....	935	325	1,695	985	1,870	11.1	14.7
*1:1.5:4.5	....	14.7	....	2,355	....	3,260	....	3,190	..	15.7

Note—The percentage by weight of MgO in 1:0.5:1.5 and 1:⅔:1⅓ is but very little greater than the percentage by weight of Portland cement in 1:1.0:3.0 and 1:1⅓:2⅔, respectively.

*MgO proportioned by weight, making weight percentage of MgO equal weight percentage Portland cement in 1:1.5:4.5 and 1:2:4

TABLE II—COMPOSITION, CONSTITUTION AND TEMPERATURES OF BURNING OF CALCIUM-ALUMINATE CEMENTS

All Composition in Per Cent.

Cement No.	1	2	3	4	5	6	7	8
SiO_2	0.44	0.76	9.41	10.48	17.23	17.38	11.[illegible]3	0.6[illegible]
Al_2O_3	62.31	61.25	55.09	46.71	39.96	30.52	47.66	74.11
Fe_2O_3	0.51	0.60	2.04	2.13	2.57	1.85	3.10	[illegible]
CaO	36.6[illegible]	36.32	30.73	39.79	38.84	46.72	[illegible]1.8[illegible]	2[illegible].8[illegible]
MgO	0.36	0.18	2.95	1.04	1.29	2.27	3.66	[illegible]
Ignition loss	0.[illegible]7	0.50	0.08	0.32	0.14	0.78	0.17	0.[illegible]8
	100.38	99.91	100.30	100.47	100.03	100.52	100.1[illegible]	[illegible]
Temperature of burning, deg Cent.	1460	1480	1490	1380	1455	[illegible]360	1445	15[illegible]
Constituents	3C 5A CA 2CS	CA 5C 3A 2CS	CA 3C 5A 2CAS	2CAS CA 2CS	2CAS CA 2CS	2CS 5C 3A CA	2CAS CA 2CS	CA 3C 5A 2CAS

[1] C = CaO; A = Al_2O_3; S = SiO_2.

TABLE III—TIME OF SETTING AND FINENESS OF CALCIUM-ALUMINATE CEMENTS

Cement No.	Initial Set Gillmore hr.	min.	Vicat hr.	min.	Final Set Gillmore. hr.	min.	Vicat hr.	min.	Per Cent Passing 200-Mesh
1	0	55	0	25	1	15	2	1	83.[illegible]
2	[illegible]	20	[illegible]	12	2	0	[illegible]	50	80.0
3	[illegible]	[illegible]	5	15	*		7	0	81.2
4	[illegible]	25	—		3	[illegible]0	1	1[illegible]	78.0
5	0	[illegible]0	0	15	4	45	3	15	8[illegible].2
6	0	7	0	2	0	45	0	12	76.4
7	[illegible]	0	3	45	*		*		79.[illegible]
8	7	0	3	30	*		*		86.6

*Final Set between 8 and 16 hours.

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*In carrying out the investigation presented here, no addition of SO_3 in any form was made to the cements. Work carried on at the same time as this presented here showed that such additions accelerated the time of set and caused a reduction in both the tensile and compressive strength.

the $3CaO.\ 5Al_2O_3$ will give the most and the $5CaO.\ .\ 3AL_2O_3$ the least. This hydrated alumina is, as is well known, a colloid and, when formed under the conditions indicated above, constitutes the greater part of the cementitious material of these compounds.

The higher the alumina content in any of the aluminates, the slower will be the reaction with water and consequently the slower will be the time of setting. This is shown in Table III, but not very clearly unless studied in connection with the relative amounts of the constituents shown in Table II. The former table shows that cement No. 3 has a slower setting time than cements Nos. 1 or 2, and also a lesser alumina content. The latter table, however, shows the presence of a large amount of silica and therefore the presence of a quantity of silicate which reduces the amount of alumina in the former cement and also retards the setting time. The two silicates present in these cements react very slowly with water, in fact, the ternary compound $2\ CaO.Al_2O_3.SiO_2$ reacts so slowly that it will not form a cementing material, while the orthosilicate, $2\ CaO.SiO_2$, at the end of a year shows but little more than 5 per cent water of hydration but a very satisfactory strength. Also a comparison of cement No. 8 with cements Nos 1 and 2, or cement No. 7 with Nos. 5 and 6 will confirm the statement that increasing alumina content gives a slower setting cement. This has been more strikingly shown in other work carried on with the pure compounds when it was found that the tricalcium aluminate—the aluminate lowest in alumina—alwys gives a flash set.

With the exceptions of cements Nos. 2, 3 and 8, the burning temperatures used were either those generally used in burning Portland cement or a little lower. The temperatures used in these three exceptions were not much in excess of that infrequently used in making the latter cement and can be comparatively easily reached in a rotary kiln. One point in particular should be noted: it is impossible to produce an unsound cement unless a temperature far below that used in Portland cement practice were attempted. Slight underburning or burning at a temperature of 100° lower than that given would have produced an aluminate lower in alumina and free alumina.

Table V shows the strengths produced by the cements when tested in the form of a 6 by 12-in. cylinder as a 1:1½:4½ gravel concrete. In order that some idea may be obtained in a comparatice way of their deportment as a mortar, the compressive strengths of some 1:3 standard sand 2-in. cubes are given in Table IV. Previous work showed that, on account of the large amounts of colloidal material formed in the process of hardening, retrogression is likely to be shown by any specimens stored continuously in water or the damp closet. At certain periods, therefore, some of the specimens were removed from the water or damp closet and placed in the air of the laboratory until broken.

These two latter tables very clearly show the high 24-hour strengths. Special mention should surely be made of strengths of 2,800 to 3,100 lb. per sq. in. for a 1:6 concrete at the end of 24 hours. The strengths of some of the 1:3 mcrtars at the end of the same time is just as unusually high. The gain in strength with aging is also quite large although maximum strength is reached at a comparatively early period. Consequently some very phenomenal strengths for either kind of a specimen are developed. A compressive strength of 8,610 lb. per sq. in. at seven days for 1:3 mortar or 6,010 lb. at the same period for 1:6 concrete are surely striking. While these results represent some of the maximum ones obtained, there are many other very exceptional high strengths shown in the tables, when these are compared with the results generally obtained with Portland cement.

An examination of the tables shows that the maximum strength for the water or damp closet stored specimens was attained at some period previous to one year. As stated before, the quick hardening is due to a great amount of hydrated material rapidly formed. This is also in the colloidal form and will, therefore, in the presence of excess water, take up in a comparatively short time such an excess of the latter that there is a reduction in strength. It will not take up enough from air of the usual humidity to materially affect the strength. It does, however, lose water to the latter to a certain extent. It is this latter loss of water with consequent drying out of the colloid which causes the increase in strength of the water-air or damp closet-air storage over the storage in the water or damp closet alone.

It is interesting to note that in the case of the mortar specimens, cements Nos. 3, 5 and 6 developed the highest strengths by the combined method of storage at the end of the 26-week period, while the other cements developed their maximum strength by this method of storage at 28 days. Apparently, therefore, the latter were much quicker hardening than the former. Concrete specimens aged by the combined method were broken only at the one-year period. At this period by this method of storage maximum strength was developed by all the cements except Nos. 4 and 2. These latter developed maximum strength by damp closet storage at 7 and 28 days respectively. The continued storage of these two in the damp closet until removed to the air apparently caused such excessive hydration that subsequent drying out could not cause sufficient gain in strength to bring back the maximum strength shown at the earlier period.

After the high results of the 1:6 concretes were obtained, it was thought desirable to make some leaner concretes. Consequently a 1:3:9 gravel concrete was made, using certain of the cements of which there was a sufficient amount available. Even such lean concretes developed surprising strengths in several cases. This is especially true of cement No. 8, which developed a strength of 3,415 lb. per sq. in. at 28 days and 3,980 lb. at 90 days, and a maximum strength, by the combined storage, of 4,445 lb. per sq. in. at one year.

In conclusion it may be stated, therefore, that the aluminates of lime, even when they contain such amounts of impurities as 10 per cent silica and 3 per cent iron oxide, constitute a material which is a very valuable cementing medium when gaged with water. This particular value lies in the high early strengths which they develop. The greater the amount of the alumina present, as an aluminate of lime, the greater will be the early strength. Under certain conditions of curing there is a marked increase of strength with age, but this does not extend over a very long period of time. It also appears that if the concrete is subjected to an excess of water during curing there will be a decrease in strength. Such amounts of moisture as are usually present in the air do not materially affect the strength. It appears, therefore, that these cements might be of considerable value for certain special uses, where the principal requisite would be quick hardening.

TABLE IV.—COMPRESSIVE STRENGTH OF 1:3 STANDARD SAND MORTARS, FROM CALCIUM-ALUMINATE CEMENTS

All values in pounds per square inch.

Tested at	24 hrs.	7days.	28days.	28days.	90days.	26 weeks		1 year.
Stored in	Water			C. S.	Water.	Water.	C. S.	Water.
Cement No.								
1....	3570	5945	3765	6815	3945	5330	6015	3045
2....	4260	4760	3945	7625	4735	4570	5290	4430
3....	2240	4940	6475	8000	7180	7760	11050	5315
4....	4410	4880	5285	6400	4565	3470	3480	3200
5....	1035	1400	1820	2875	2070	2900	3845	2410
6....	1340	1260	1425	3130	1680	1895	4345	2310
7....	2165	5140	3930	7085	5205	3605	6090	5225
8....	2860	8610	7845	10690	8260	6380	8045	8945

C. S. = Stored for one-quarter of period in water and the remainder in the air of the laboratory.

TABLE V.—COMPRESSIVE STRENGTH OF 1:6 AND 1:12 GRAVEL CONCRETE, FROM CALCIUM-ALUMINATE CEMENTS.

All values in pounds per square inch.

Tested	24 Hours.		7 Days.		28 Days.		90 Days.		26 Weeks.		1 Year			
Proportions[2]	1:6	1:12	1:6	1:12	1:6	1:12	1:6	1:12	1:6	1:12	1:6	1:6[1]	1:12	1:12[1]
Cement No.														
1	2825	....	3270	....	3310	....	4150	....	4180	....	3310	5590	....	....
2	3000	....	4150	....	4740	....	2480	....	1760	....	1760	2360	....	....
3	Soft	....	2175	....	3680	....	3900	....	4525	....	4135	5660	....	...
4	3145	880	3570	1005	3370	1000	2930	875	2565	800	2965	3280	860	1275
5	310	Soft	885	225	1250	365	1050	390	1270	550	1460	2110	570	870
6	840	275	765	275	990	305	1260	400	1515	470	1440	2035	470	810
7	1475	455	4135	1405	4625	1500	4640	1600	4450	1580	4650	5300	1350	1815
8	2930	890	6010	2270	7060	3415	7050	3980	7610	3910	6720	8220	3930	4445

[1] All specimens in these columns were stored for the first 4 months in the damp closet and for the remainder of the period in the air of the laboratory. All other specimens were stored in the damp closet for the entire period aged.

[2] Contained 3 per cent plaster.

The Treatment of Factory Roof Timbers

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The exact method of treating timber in order to get the best service for the roofs of paper and cotton mills and of other buildings where high humidity conditions cause rapid decay has never been worked out. A number of excellent preservatives are known and their use has been recommended from time to time. There are practically no records of the service given by treated roofs, so all recommendations have to be based on information available with respect to the other uses of treated timber. Specific recommendations are difficult on account of the wide variation in local conditions, such as the amount of timber to be treated, the expense permissible, insurance regulations, and the availability of treated timber. Several different methods of treatment are possible and the circumstances surrounding each individual case should influence the choice of method to be used.

Untreated Timber.—Untreated roofs of non-durable wood, such as spruce, hemlock, or sappy pine, are cheapest in first cost; but, if the humidity in the building is high they decay rapidly and soon need to be replaced. The need for frequent replacement may make them more expensive than roofs whose first cost is considerably higher.

Some woods are naturally much more durable than those mentioned, and they may sometimes be used to advantage where circumstances preclude the use of treated timber. The most durable American woods which may readily be secured in quantity for roofing purposes are redwood, bald cypress, Port Orford cedar, and western red cedar. In using these species care should be taken to select heartwood only, as their sapwood is not very durable.

Treated Timber.—Methods of treating timber with preservatives vary in cost and effectiveness. Some require only very simple apparatus and the treatments can be made at the building site. Others require heavy pressure and special apparatus, and must, therefore, be made at central treating plants. The following is a brief description of two generally used treatments:

The Steeping Process.—The steeping method of treatment consists simply in soaking the timber in a water solution of the preservative. It is suitable for preservatives such as zinc chloride, sodium fluoride, and mercuric chloride. When the latter preservative is used the process is called Kyanizing. In order to treat wood to the best advantage, it should be thoroughly seasoned and dry. It is customary to allow it to remain in the preservative one day for each inch in thickness, and then one additional day. A still longer soaking period would probably be advantageous if time would permit. After treatment the timber should be air-dried again before being used.

The cost of this treatment will vary with the cost of labor, preservative, character of timber, etc. It is stated on good authority that under prewar conditions mill construction timber was treated with mercuric chloride for about $3 per 1,000 ft.

On account of the differences in the degree of absorption and penetration of the preservative, and because of other factors that affect durability, no definite figures can be given regarding the extent of life that may be anticipated for timber treated by steeping processes. In factory roofs, however, treated timber may be expected to be much more durable than untreated timber of the same species, and the additional life should well repay the cost of treatment.

More specific directions for the steeping process, especially concerning the use of mercuric chloride, should be obtained before attempting to make treatments. These directions may be had upon application to the Forest Products Laboratory.

Non-pressure Creosote Treatments.—There are several ways* of applying coaltar creosote with simple apparatus. Briefly, they are as follows:

Brush treatment consists in applying hot creosote to the wood with a brush. The wood should be well seasoned and dry, and the oil should be flooded upon the wood and into all checks and crevices. Two coats are better than one. Relatively little absorption and penetration of oil will be obtained by this treatment, but it should add from two to five years to the life of roof timber, if the work is thoroughly done.

The dipping treatment consists in completely submerging the lumber in a tank of hot creosote for 5 to 15 minutes. It accomplishes the same result as brush treatment, but in a more thorough mannner.

Hot and cold bath treatment consists in first submerging the lumber in hot creosote for several hours, and then either allowing the oil to cool down slowly with the wood in it or suddenly plunging the wood into cool oil for several hours. This is a more expensive treatment than any of the previous methods on account of the greater costs for labor and apparatus, and the greater absorption of preservative. It is also more effective in preventing decay.

Pressure treatments are the most expensive, but they are the most effective, because they result in the greatest absorption and penetration of preservative. They are suitable for either creosote or water soluble preservatives, such as sodium fluoride and zinc chloride. For roof planking an absorption of 8 to 12 pounds of creosote, or one-half pound of zinc chloride of sodium fluoride per cubic foot of wood treated should add 20 years at least and probably more to the life of the timber. The cost of treatment may best be obtained by securing quotations from wood preserving companies.**

Characteristics of Preservatives.—The various preservatives mentioned have different characteristics which should be kept in mind in considering their use.

Coal-tar creosote is objected to by some insurance companies as a fire hazard. It is not believed, however, that it adds greatly to the inflammability of the wood. It has an odor which may be objectionable in food-storage rooms, as some foods are very sensitive to odors. It should not be objectionable to workmen, however, in the small amounts which would be present in buildings. Moreover, the odor is pleasing to some people. Creosoted wood cannot be successfully painted over, as the oil quickly comes through the paint and discolors it.

If the creosoting is not properly done when the pressure process is used, or a heavy absorption is obtained in the hot- and cold-bath treatment, some of the oil may exude from the wood and drip. This is commonly called bleeding, and is very undesirable where the drops of oil may cause damage to such products as cotton cloth or paper. It may be largely prevented by steaming the wood in the treating cylinder after the injection of the oil. Allowing the lumber to air-dry thoroughly in open piles after treatment will also help. As an additional precaution, the under side of the roof may be painted with water glass, or sheathed temporarily with thin, untreated lumber. No difficulty from bleeding should be encountered in using dipped or brush treated lumber.

Zinc chloride appears to attack lead paints, and they do not last very long on zinc treated wood; otherwise zinc treated wood is very desirable.

Sodium fluoride does not attack paint and in most other respects is very desirable. It is colorless and odorless and does not bleed. It is not yet extensively used, however, and it will probably be found difficult to secure wood that has been pressure-treated with this preservative.

The chief disadvantages of mercuric chloride (corrosive sublimate) are its poisonous nature and its corrosive action on steel. The latter fact prevents the use of steel tanks for treating with mercuric chloride solutions, but neither of these things should discourage the use of this preservative.

Precautions in Using Treated Timber.—The effectiveness of treated timber depends upon maintaining a complete envelope of treated wood around the untreated interior of the board. If this treated layer is broken through decay can enter and destroy the untreated interior in spite of the treated outer layer. For this reason it is desirable to have the lumber cut to final dimensions before treatment. Whenever it becomes necessary to cut into treated timber the untreated wood exposed by cutting should be given two coats of creosote or a treatment with some other preservative.

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*Detailed descriptions of them may be found in Farmers' Bulletin 744, "The Preservative Treatment of Farm Timbers," which may be obtained free from the Division of Publication, U. S. Department of Agriculture, Washington, D. C.

**The names of companies located in any particular region may be obtained from the Secretary of the American Wood Preservers' Association, Mt. Royal Station, Baltimore, Md., or from the U. S. Forest Service, Forest Products Laboratory, Madison, Wis.

How to Apply for a Job

Some excellent suggestions on selling personal services, based on the experiences of the employment department of the American Association of Engineers, are given in the July Monad, the official publication of the Association. The matter following is abstracted from the above mentioned paper.

Selling by Letter.—First, use plain paper (preferably not the letterhead of your present employer) of good quality, and business size (8½x11 in.). Employers are apt to throw tinted or perfumed notepaper into the waste basket. Use a business envelope of one of the standard sizes, and not a social envelope. Fold your letter neatly and crisply. If possible, typewrite your letter, otherwise write legibly in ink, without erasures or alterations. Never use pencil and never mail a letter with scratched-out words. Be sure that the punctuation, spelling and grammar are correct. Careless writing, poor grammar and misspelled words make a very bad impression on prospective employers.

Second, make your letter short, concise and to the point Limit its length to one page. If a second page is necessary, use a second sheet of paper; do not write on both sides of the first sheet. If you wish to send a full statement of your experience, make it up as a separate document and enclose a copy. Refer to that statement in your letter, calling attention to any points you wish to emphasize. It is best to refer particularly, of course, to experience along the same line as the position under consideration: for example, in applying for a position as instrumentman, refer to previous experience as rodman or levelman rather than to a job you may have held in a shoe store. Do not forget to put your full address and the date in the upper right-hand corner. In order to prevent errors in reading your signature, it is often wise to typewrite your name just below your signature.

Third, do not apply for a position you are not qualified to fill, or vice versa, for one which is not up to your standard. In the former case the employer will usually estimate you correctly from your letter, while if he employs you, he will soon find you out. In the latter case, your action tends to lower the standing of the engineering profession and depresses salaries.

Fourth, if you prepare a statement of your experience, arrange it logically. The following general form is suggested:

A—Personal Information. Name, address, telephone, age, married or single, citizenship, place of birth, etc.

B—Education.

C—Professional Experience. List positions in reverse order, i. e., put the one held most recently first. For each position give dates, salary, name and address of firm and immediate superior title, a brief description of the work you did, and reasons for leaving.

D—Army Experience. Give your army record briefly. This is coming to be of great importance by many employers.

E.—Position Desired. Type of work—location—salary—etc.

It is well not to give references until they are requested. Be careful not to "oversell"; do not appear too anxious for the position; let your prospective employer come part way Remember that the better the position, the longer is the time required to select the proper man to fill it. If you press a prospective employer too hard it is more apt to injure your prospects than to advance them.

Selling Your Services by Personal Interview.—In most cases, the early steps toward a new position are conducted by letter. However, before an employer reaches a decision, a personal interview is almost always necessary, and in some cases, all negotiations can be made in person, which should always be done if possible. When a personal interview follows correspondence, it can be assumed that the employer is already more or less interested, or he would not have granted the interview, and it only remains to convince him that you are the right man for the position. The ice is broken, he knows something of you and is favorable; you must crystallize that interest into a definite offer of a position. In the other case, when no correspondence precedes the interview, he knows nothing of you, but is open to suggestions, because he has a certain position to fill. In that case, everything depends on the impression you make

First impressions often result in quick judgment; unless the employer's first impression of you, gained in the first 30 seconds, is favorable, the interview is apt to be short and unsatisfactory. Therefore, it is essential to consider all the factors that influence him, and to make sure that you do not overlook any of them. Possibly the most important of such factors is personal appearance. A tramp could not get past the office boy, while at the other extreme a Beau Brummel is equally out of place in an engineering organization. An applicant should wear good clothes, well cut, and of good materials. They should be neat, clean and well pressed. A soiled collar, frayed necktie, baggy trousers, or a grease-spotted vest gives an impression of carelessness, as do also an unshaven face, dirty finger nails, or dusty shoes.

But appearance is not confined simply to clothes and neatness; there are many physical qualities that are important factors; carriage, alertness, self-confidence, and straightforwardness. We all admire a man that is well set up, erect, shoulders thrown back, stomach drawn in, who habitually stands and walks in the "position of the soldier" as they say in the army. We instinctively feel that such a man has proper self-respect and proper respect for others. On the contrary, we all rather look down on a man whose carriage is slouchy, who has a cigarette drooping from a corner of his mouth, or whose hat remains tilted on the back of his head.

The best modern hotels insist that their employes be courteous at all times, and emphasize one motto that does wonders to build up trade, viz., "the guest is always right." The same thing applies to an interview with a possible employer. Be courteous, not only to him, but also to his assistants and employes. Don't let a fresh office boy or an impertinent clerk rile you. Keep your poise and be courteous to all. Above all, don't argue with your man. Even if his opinions irritate you, accept them good naturedly and make him think that you value them. If he expresses a poor opinion of your qualifications, don't get indignant, he may be testing you; assume that he misunderstands and present your best points. Even if he decides not to employ you, take the news calmly and leave him thinking well of you. You may want to approach him later on another proposition.

In most interviews, a certain amount of general talk precedes the definite discussion. Follow his leads. If he wants to talk baseball, discuss it with him; he is trying to get acquainted with you and sound you out. But when he gets ready to talk business, don't bore him with your experiences in France, but talk business. Present your qualifications clearly; don't exaggerate. If there are weak points, admit them; every man has his faults, and frankness will often offset them. Don't boast; let him infer your achievements. It is better to grow in his estimation than to start big and then diminish.

If you do not know enough of the position to be sure that you want it, ask for further information, but do so carefully. Do not let the employer think that you are investigating him or his proposition, because he likes to think that the reverse is true. It is often best not to ask questions about the position; the information will probably be given voluntarily during the interview, in which case you can withdraw gracefully if the position is not attractive. Early questions regarding duties, working hours, vacation, privileges, etc., are apt to react unfavorably on the employer. In general those things are best discussed "after the contract is signed." Salary is always the last matter to be settled, and if you have convinced the prospective employer that you are the man he wants before salary is mentioned, the final settlement is apt to be better than otherwise.

The more important a position is, the longer the negotiations before it is filled. A chief draftsman will employ a tracer after a ten-minute interview, but a railroad president may take months to select a chief engineer. Frequently several interviews are necessary, and it may be fatal to try and force quick action. In trout fishing, it is often necessary to pay out line and play the fish for half an hour. Similarly in negotiating for a desirable position, the time element is important, and matters should not be rushed. It takes time for a student to absorb a lesson in bridge design; similarly it takes time for an employer to become convinced that you are the right man. Each case is individual and thought and judgment must be used in each move. Study your man, learn all you can about him and his firm If his son at college is on the football team talk to him of it and congratulate him. Eventually he becomes convinced that you are the man he wants, or in other words, he "is sold" on your abilities, and in a few days you will be on the payroll.

Conclusions and Recommendations of American Concrete Institute Committee on Fire Resistive Concrete

Important conclusions drawn from fire tests and reports, together with definite engineering recommendations based on these conclusions, were given in the report of the Committee on Fireproofing of the American Concrete Institute, submitted at the recent convention of the Institute by Mr. Walter A. Hull, chairman of the committee. An abstract of the report follows:

Thickness of Protective Material.—The Bureau of Standards' column tests show, quantitatively, the relative effects of a standard 4-hour fire test on various types of columns made with concrete from various aggregates. A thickness of 1½ in. of concrete was provided, outside of the steel, in all cases. The steel was probably more accurately placed, in the forms, than could ordinarily be expected in actual building operations. In most of the 18-in. round columns, temperatures between 550 and 600° C. (1,022 and 1,112° F.) were reached in the steel at the end of the 4-hour fire test. In the 16-in. square columns, temperatures in the steel were above 600° C. (1,112° F.). Steel at these temperatures has lost a large part of its strength. It is evident, therefore, that 1½ in. of protective concrete is not sufficient thickness for the proper protection of the steel where 4-hour protection is required.

In three columns in which the protection had been increased to 2½ in. by the addition of cement mortar in the form of plaster, with light mesh reinforcement, the temperatures in the steel at the end of the test were approximately 400° C. (752° F.). It is, therefore, recommended that in concrete columns where 4-hour protection is required, protective material not less than 2 in. in thickness be provided, over the steel. In columns in which a high percentage of steel is used, increasing the importance of affording it ample protection, the thickness of protective material should be 2½ in. for 4-hour protection, and special care should be given to the accurate placing of the steel in the forms, to avoid inadequate protection on one side.

Fire-Resistive Properties of Different Aggregates.—Previous fire tests have indicated that there is an important difference in the fire-resistive properties of different aggregates. Ira H. Woolson, in his final report to the American Society for Testing Materials of investigations of the fire resistive properties of concrete made in 1905, 1906 and 1907, reported adversely on the pure quartz gravel which is extensively used in the vicinity of New York City. Shortly afterward, the British Fire Prevention Committee reported adversely on the behavior of gravel concrete in a fire test of floor arches. Further evidence was developed by tests made by the Bureau of Standards and reported to the American Society for Testing Materials in 1917. These test results have been so consistent that it appears to have been well established that the physical properties of gravel, that is high in quartz content, are not such as to make it as suitable as other aggregates for fire-resistive concrete.

Investigation of the failure of concrete construction in recent severe fires clearly indicates that the damage was much greater than would have been the case if any one of a number of aggregates, other than gravel of high quartz content had been used. This was especially true in the case of the fire at Far Rockaway, New York. This fire has been thoroughly investigated. A complete report of the fire and of the condition of the building, with conclusions attributing the damage in large part to the pure quartz gravel aggregate, was prepared for the National Board of Fire Underwriters by its Consulting Engineer, Ira H. Woolson. Copies of this report are obtainable. A further investigation was made by a special committee of the American Concrete Institute and a report presented by Richard L. Humphrey, dealing with the fire, the condition of the building and the methods used in reconstruction. Great importance was attached to the nature of the aggregate in this report.

To this evidence may be added that of two great factory building fires which occurred in London in 1917. Both of these latter fires were of great severity and long duration. Both were started by an explosion. It was impossible to determine how much of the damage was caused directly by the explosion but after thorough investigation the British Fire Prevention Committee attributed a large part of the damage to the inability of the Thames ballast (gravel) concrete to withstand the destructive stresses of a severe fire, as is shown by their reports, from one of which the following two paragraphs may be quoted:

"It is clearly shown that Thames ballast or gravel concrete is an unsuitable material for reinforced concrete in buildings where the risk of a severe fire has to be considered.

"Where a suitable aggregate or combination of materials is used in the future and the reinforcement accorded proper protection, only superficial damage need be expected, i. e., damage repairable without extensive reconstruction."

In the fire tests of concrete columns made by the Bureau of Standards gravel concrete columns were shown to be greatly inferior in fire resistance to columns having no other aggregates. While this applies to all types of columns, the contrasts were greatest in round columns, vertically and spirally reinforced and in vertically reinforced square columns. It is probable that similar results would be obtained from all gravels made up largely of highly silicious materials such as sandstone pebbles, quartz pebbles and granite pebbles.

Measures for Preventing Serious Damage.—It is clearly indicated that serious structural damage by fire in concrete buildings could be prevented in large measure by using, where it is economical to do so, either limestone, trap rock, blast furnace slag or burned clay aggregate and, where none of these aggregates can be used economically, by paying special attention to certain structural details. In the case of columns, there is evidence that vertically reinforced round columns, without spiral, resist fire better than square columns without spiral. This applies particularly to gravel concrete columns. It does not appear to be true of columns made from the more suitable aggregates. Gravel concrete columns having spiral reinforcement appear to be particularly susceptible to spalling. It has been found that the addition of 1 in. of cement plaster, held in place by light metal mesh, was sufficient to prevent the loss of the protective covering by spalling in the cost of spirally reinforced gravel concrete columns, and that columns so protected lost but little of their original strength in the 4-hour test. There seems to be added merit in such protection in the fact that the thickness is uniform over the columns, whereas any inaccuracy in placing steel would result in protective concrete being thinner on one side than on the other.

The following recommendations are therefore made, pending further developments along this line:

1. That for fire-resistive construction, limestone, trap rock, blast furnace slag and burned clay be given a preference over highly silicious gravels.
2. That in cases where gravel aggregate is to be used, with no additional protective material over the concrete, round columns be given a preference over rectanguar ones.
3. That where gravel aggregate is used, all columns, but especially rectangular columns and round columns with spiral reinforcement, be given the additional protection of approximately 1 in. of portland cement plaster either on metal lath or reinforced by light expanded metal.

New Building Law for First Class Cities in Pennsylvania

A new law relating to building construction in cities of the first class in Pennsylvania was signed May 8 by the Governor. The act, among other things, prescribes the minimum live loads to be considered in designing buildings, specifies the factors of safety, and regulates the thickness of brick walls in dwellings. The live loads specified are as follows:

Forty pounds for residence buildings; 100 lb. for public buildings or places of assembly, except that for classrooms of schools or other places of instruction the floor need not be designed for more than 75 lb.; 120 lb. for business buildings, except that the floors of offices need not be designed for more than 60 lb.

The law also provides that every steel floor beam in any building, hereafter erected or altered, used for any business purpose shall be capable of sustaining a live load concentrated at its center of at least 4,000 lb.; that roofs shall be proportioned to bear safely a live load of 3 lb. per square foot of surface; and for yards and courts inside the building line, the live loads shall be taken at not less than 120 lb. per square foot.

Other provisions of the act are:

The factor of safety shall be as 1 to 4 for steel, wrought iron, and timber, and concrete; and as 1 to 6 for cast iron; and as 1 to 10 for natural or artificial stone and brick or stone masonry. All calculations shall be based upon the actual sizes of the materials and not the nominal sizes.

The minimum thickness of any wooden floor, joists, or roof rafters shall be 2 in., provided such joists or rafters are not more than 12 in. in depth.

Doubtful classification: In case any building is not herein specifically provided for, or if there is any uncertainty as to its classification, its status shall be fixed by a rule promulgated by the chief of the Bureau of Building Inspection.

All buildings, used exclusively as dwellings for one or two families, not over 20 ft. in width and 60 ft. in length, having a height not exceeding 26 ft., may have brick walls 9 in. in thickness: Provided, That is any such walls are party walls, the adjoining lot shall not be encumbered with more than 9 in. of stone wall and 4½ in. of brick wall.

Bonding New Cement Mortar and Concrete to Old Concrete

It frequently is necessary in construction and repair work to join fresh concrete to old or to concrete which has partially set. In order to obtain definite data on the relative value of various methods of increasing the bond an extensive series of tests have been carried out in the Engineering Research Laboratory of the Bureau of Public Roads. This series included:

1. Tests on the bond strength in tension of a 1:2 mortar in the form of the standard tension briquette.

2. Tests on the bond strength in cross bending of a 1:⅔:1⅓ concrete in 4 by 4 by 14-in. prisms bonded to concrete slabs.

3. Tests on the bond strength in shear of a 1:⅔:1⅓ concrete in specimens in the form of 8-in. diameter cylindrical disks, 2 in. high.

4. Tests on the permeability or water-tightness of the joints formed by various bonding methods. The same specimens were used in this series as in the shear tests.

The conclusions drawn from the tests are summarized as follows by W. E. Rosengarten, U. S. Highway Engineer, Bureau of Public Roads, in a recent publication of the Bureau.

Bond Strength in Tension.—It may be safely stated that the ability of fresh mortar to adhere to older material decreases rapidly as the old sets up. Where the older material has set for 24 hours before adding the fresh, the bonding strength is but 44 per cent of that of monolithic construction. Further ageing of the old mortar causes a slight decrease in the bonding ability, which at 7 days is 39 per cent of the original, and at 28 days has reduced to 35.5 per cent.

The bond of new concrete to old can, however, be increased by various methods, which include treatment of the old surface, the use of a bonding medium, and care in handling the new concrete.

The old surface can be treated to increase the bond either by roughing with a steel tool or by a treatment of dilute hydrochloric acid (1:10 concentrated acid and water). The acid acts on the cement particles, dissolving them and leaving the clean surfaces of the aggregate. The remaining salts should be washed off thoroughly. Roughing the surface increases the strength of bond 20 per cent, and the acid treatment increases it 13 per cent, except in the case of the tests where the old concrete has aged 7 days, in which case there appears an unexplainable detriment to the bond due to the acid treatment. Combining both roughening and then treating with acid gives but a slightly greater bonding ability than either by itself.

The application of a thin layer of cement butter as a bonding medium has a decided effect in increasing the adhesive strength. An additional 25 per cent in strength is developed by the addition of the cement butter layer. If the cement-butter layer is allowed to stand one hour prier to adding the fresh mortar, an additional 3 per cent may be added to the strength. The use of a proprietary compound mixed in with the neat cement butter appears to be of little additional value.

The hard tamping of the new mortar against the old, thus forcing it into the pores, has a tendency to increase the strength of bond about 8 per cent.

The broken surface showed a greater bond than either the plain molded or natural surface, as might have been expected. The roughing of the two latter characters of surface had the effect of placing them on a par with the broken surfaces.

The ability to bond to the molded and natural surfaces appeared about equal. A tendency, however, is noted in the case of the surface molded against forms toward a decrease in the strength as the age of old concrete increases, while the natural surface appears to remain fairly constant after the concrete has aged 24 hours.

The effect on the bond of wetting the old mortar surface is hard to determine from the results of these tests. It is at present the usual practice to wet the old work thoroughly before attempting to bond fresh mortar to it. In about half the above tests this appears to have a detrimental effect, decreasing the bond strength about 10 per cent, while the other half shows it to have increased the bond strength 5 per cent.

The use of a bituminous bonding material is of little value.

The use of sodium silicate appears to have an effect on the bonding strength.

Bond Strength Cross-bonding.—The use of the hydrochloric acid wash on the concrete specimens appears to give a slightly greater bond than does the mechanical roughing of the surface. In the case of the mortar briquettes the opposite was the case.

The old concrete surface wetted develops a bond of only a little over one-fifth the strength of the monolithic concrete, roughing the surface or giving it a hydrochloric acid treatment increases the strength one-sixth and the application of a cement-butter layer adds an additional one-fifth.

The results of this series of tests show the wetting of the concrete to be beneficial. The suggested theory that the cement particles are drawn into the old dry concrete by capillary action, thus increasing the bond, does not appear to be borne out by the tests.

The ability of the fresh concrete to adhere to the old decreased rapidly during the early stages of setting of the old concrete, from 100 per cent to about 30 per cent in the first 24 hours. After the old concrete has taken its final set the decrease with the age is very slight.

In general, it appears that (a) by careful treatment new concrete can be made to adhere to old with a strength equal to 60 per cent of monolithic concrete. If a greater bond than this is desired it will be necessary to resort to dowels drilled into the old concrete.

(b) If no special treatment is given the old concrete other than cleaning off foreign substances before adding the fresh concrete, a bond of but 20 per cent of the monolithic concrete is developed.

(c) The surface of the old concrete can be roughened or treated with a 1:10 dilute solution of hydrochloric acid which will increase the bond by 20 per cent of the strength of the monolithic concrete.

(d) A bonding medium of a thin layer of neat cement butter spread over the surface of the old concrete will increase the bond 20 per cent of the strength of the monolithic.

(e) Tamping the fresh concrete hard against the old concrete, forcing the cement into the pores, increases the bond 5 per cent of the strength of the monolithic concrete.

It must be remembered that the above conclusions refer to a rich concrete—namely, 1:2/3:1—1/3, and that for leaner mixes the percentages very likely would be increased.

Shearing Strength.—The shearing strength of a joint is greatly increased by a treatment of the surface of the old concrete, and although it may slightly increase the cost of the work, the added effect would certainly seem desirable.

Pearmeability.—The results of this series show that there is no danger of leakage at a joint made in concrete of a mixture as rich as 1:2/3:1—1/3, under pressures up to 40 lb. per square inch; when the surface of the old concrete has been treated.

Application of Stuccos

Interesting information on the application of portland cement stucco was given in the report of the Committee on Treatment of Concrete Surfaces, submitted last month at the annual meeting of the American Concrete Institute. The following is abstracted from the report:

The use of hair, lime, and waterproofing materials, the variations in the mixtures for the different coats, the number and thickness of the coats, the intervals between the coats, the degree of wetting of the undercoats, and the precautions necessary in protecting the coats from too rapid drying, are details subject to question, and all will stand further investigation. However, the study of the experimental panels at the Bureau of Standards has yielded considerable information on some of these points.

One of the most important indications from these panels is that lean mixtures containing well graded aggregate give better results than those commonly specified. Mixtures as lean as 1 part of cement to 6 or 7 parts of graded aggregate have given excellent results in these tests. The committee is of the opinion that the volume change of rich mortars is accountable for much of the unsightly cracking of stuccoes, and that no mixture should be used in which the proportion of cement is greater than 1 part to 3 parts of fine aggregate.

The effect of hydrated lime in cement stucco has also been given considerable attention, and the conclusion which is forcing itself upon the committee is that hydrated lime does not improve the structure of the stucco, but by imparting better working quality to the mortar, reduces the cost of application. On the other hand, there is evidence that not more than 20 per cent of hydrated lime, by volume of the cement, should be added to cement stucco if the best results are to be obtained.

There seems to be no good reason for varying the composition of the different coats, but if a variation is to be specified, the scratch coat should logically be the strongest mixture followed by a leaner brown coat, and a still leaner finish. No greater mistake has ever been made in stucco application than the use of a strong brown coat over a weak base or a weak scratch coat. The not uncommon practice of applying a strong brown coat over a lime mortar scratch coat has been responsible for many stucco failures.

The suggestion that the finish coat should logically be leaner than the undercoats immediately brings up the waterproofing question. There are two fundamental points to be considered in this connection; first, that the lean coat is not necessarily lacking in density, and second, that the waterproofing problem in good cement stucco is not one of overcoming permeability, but rather of reducing absorption. The entire question hinges on absorption, and the evidence at hand indicates that a moderate degree of absorption is a much more preferable condition than a surface covered with craze and map cracks produced by the use of a too rich or wrongly manipulated finishing coat. Any waterproofing treatment that alters the natural texture and color of the stucco may be dismissed from consideration, and the merit of any integral waterproofing in stucco is exceedingly difficult to determine.

The question as to number and thickness of coats may be best answered by assuming that each coat of stucco has its own particular function. The scratch coat is the first applied, and its purpose is to form an intimate bond and a secure support for the body of the stucco. On metal lath it also serves as a protective coat, and it should therefore be strong and not too lean. The use of hair or fiber is of questionable value. Hair or fiber should not be used when the space back of the lath is to be filled, and is probably not a necessary ingredient in any case. The committee at the present time would sanction its use only in scratch coats on wood lath, or on metal or wire lath that is to be back plastered, or on metal or wire lath that is applied over furring deeper than ⅜ in. The thickness of the scratch coat should average about ¼ in. over the face of the lath.

The function of the second coat (commonly called the brown or straightening coat) is to establish a true and even surface upon which to apply the finish. It forms the body of the stucco, and must fill the hollows and cover the bumps of the scratch coat. For this reason an average thickness of ⅜ in. to ½ in. will usually be required. The brown and finish coats, or the scratch and brown coats, are sometimes combined in two-coat work, which is permissible when the base upon which the stucco is applied is fairly true and even, or, when, on account of cost considerations, the best obtainable finish is not required. It is difficult, however, to obtain a satisfactory finish on a coat which runs ½ in. or more in thickness, since the tendency of a heavy coat to bag and slip is likely to produce an uneven surface.

The finish coat serves only a decorative purpose and has no structural value. Its function is solely to provide an attractive appearance, and any mixture or any method of application that may detract from the appearance, or in any way injure its permanency, should be avoided. Herein lies the argument for lean mixtures, which are more likely to be free from unsightly defects than rich mixtures, and are also more likely to improve in appearance under the action of the weather. The finish coat should be as thin as possible consistent with covering capacity, and may vary from ⅛ in. to ⅜ in. in thickness, depending upon the type employed.

It is obvious from the foregoing that first-class stucco should be 3-coat work, each coat serving its own particular purpose. The bond between the brown coat and the scratch coat needs to be strong in order to carry the weight of the body of the stucco, and for this reason it is now considered preferable to apply the brown coat the day following the application of the scratch coat. Except in dry or windy weather little wetting of the scratch coat should be necessary when the brown coat is to follow within 24 hours. A slight degree of absorption of "suction" in the scratch coat, is probably better than complete saturation, for the brown coat, as well as the others, is necessarily mixed with a larger quantity of water than it requires for maximum strength. The removal of a portion of this excess water by the suction of the undercoat not only improves the quality of the coat, but also insures a better bond by tending to draw the fine particles of the cement into the pores and interstices of the undercoat.

Whereas the interval between the brown coat and scratch coat, as recommended above, is relatively short, the interval before applying the finish coat should be as long as permissible under the conditions of the work. The reason for thus delaying the application of the finish is to enable the body of the stucco to obtain its initial shrinkage and a nearer approach to its final condition of strength and hardness, before being covered with the surface coat. The bond of the latter needs to be intimate rather than of maximum strength and if the body of the stucco has been allowed to thoroughly set and harden, it may be assumed that the finish coat is less likely to be disturbed by subsequent volume changes in the undercoats. A week or more should elapse between the application of the brown and finish coats.

The finish coat should be applied over a damp, but not saturated, undercoat, for excess water is likely to injure the bond seriously. Certain types of finish, such as the wet mixtures used for sand spraying, or for the "spatter dash" finish, may preferably be applied to a fairly dry undercoat, since suction must be depended upon to prevent streakiness and muddy appearance. The fact that finishes of this type applied in this manner may set and dry out with little strength is not serious; they gradually attain sufficient hardness with exposure to the weather.

Curing of the undercoats by sprinkling, and protection of finish coats against sun, wind, rain and frost by means of tarpaulins are always to be recommended. This is not always feasible, however, and the architect should be content to specify and insist upon reasonable precautions. The application of cement stucco in freezing weather should be avoided, and in fact temperatures slightly above the freezing point may allow frost to form on a damp wall. The application of stucco under such conditions is likely to result in failure.

Steel Hull Floating Pile Driver.—The Eucyrus Co. has recently sold to the Government of the Philippine Islands, a large floating pile driver with a steel hull for driving concrete piles for the construction of docks. This is the second pile driver of its type that has ever been built. The first built by this company was used for harbor improvement and dock construction in Halifax, Nova Scotia.

Condition of Research Work in the United States*

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Research work, quite general before the present war, became more extensive in overcoming the dastardly appliances of the Hun in devising new apparatus, products and manufacturing methods and in improving quality and production. The war has demonstrated, if demonstration was necessary, the value of research, and it is now the opinion of most of us that this stimulating viewpoint should not be lost and that the wartime interest should be continued.

The cost of research in the past has been such that in many cases it could only be undertaken in an extensive way by large corporations. The necessity and value have been evident but the small plant has been unable to inaugurate that which it has known to be of value. In other instances there have been investigations which have been of such a nature that there would be no commercial gain from their results, although of great use to mankind. The necessity of such work has been clearly seen and appreciated by some, and in this country institutions and foundations have been established by public-spirited citizens to carry on investigations or to give grants to those who are working on problems for the general good. The reference is to such organizations as the Rockefeller Institute for Medical Research, the Carnegie Institute of Washington, and the Sage Foundation.

A number of private commercial laboratories have been undertaking commissions for clients, but recently the plan worked out years ago by the Associated Factory Mutual Fire Insurance Companies of New England in their co-operative laboratory and the Insurance Engineering Experiment Station has been applied in the co-operative work of certain industries These investigations have been undertaken by an industry as a whole or by group of manufacturers, and the results have been distributed among the contributors to the expense funds, or, in certain cases, the results of the experiments have been freely given to the world.

Research in Technical-School Laboratories.—The general equipment of the university laboratories is planned to give training to the undergraduate in methods and to illustrate certain laws. The engineering laboratories are equipped so that research work is possible, but in many cases the schedule for instruction work is so heavy that little or no research work can be done. Nevertheless, under these adverse conditions some work of great value has been produced during the last 30 years in the technical schools by faculty members, graduate students and even by undergraduates. The lack of time for experimentation has been cared for in the engineering experiment stations by the employment of full- or part-time investigators. In this way work can be carried on continuously to a conclusion. At present the disorganization of these laboratories by war activities has caused most of the work to cease. A return to normal conditions, however, is looked for within a year. The laboratories of chemistry, physics, biology and the other sciences have been doing much graduate research work. This has been of a theoretical nature rather than of the applied form of research more evident in our engineering laboratories. The small number of graduate students of engineering has partially accounted for the limited amount of research from the engineering schools.

The equipment of these technical schools is usually quite diversified and adapted for research work of a varied nature. The equipment has been planned in many cases for certain problems and in some instances contributions have been made by some associated industries for equipment to make investigations of problems of that industry. Thus, at Johns Hopkins University the gas interests in and around Baltimore donated a fund for the equipment of a laboratory to study gas manufacture and its by-products. At the Carnegie Institute of Technology at Pittsburgh a laboratory for rolling-mill research and instruction is being established from funds which are contributed by a number of steel manufacturers.

One of the great needs of the present time as voiced by directors of a large Government laboratory and of a large commercial laboratory is the need for more research men. Research demands a man of clear vision, great imagination, tremendous resources, absolute honesty, good training and devotion to work. The love of the work will have to be the incentive, as in many cases the monetary returns are small. If our colleges of engineering and science could by some means instill into more men the great desire for discovery through research they would aid much in the contributions of this age to the future. Training is also necessary, and that should be done by men engaged in research.

Engineering Experiment Stations.—To aid the work of research for the industries and manufacturers by supporting men on whole or part time to carry out investigations, engineering experiment stations have been established in many state universities. These have been active and the development of such institutions is considered by some to be of such national importance that several bills have been introduced in Congress for Government aid in establishing them throughout the United States.

The Engineering Experiment Station of the University of Illinois, organized in 1903, usually comes to mind when discussing this question, although there are fourteen such stations at other state universities. The Engineering Experiment Station of the University of Illinois up to January, 1919, has issued 110 bulletins and 10 circulars on its researches. Twenty-eight of these deal with structural problems, 28 with problems relating to fuel, its mining, storing, combustion and analysis, 10 with problems of mechanics, strength of materials and machine design, 14 with heat problems and 11 with problems of electricity and electrochemistry. These papers are sent free of cost to interested parties in some cases, and in other cases a nominal charge is made.

Co-operative Research.—While discussing the subject of the experiment station, the possibility of the co-operative research as shown by present conditions and thedifferent methods of solving this problem should be mentioned. The problems of hot-air furnace heating have been solved by empirical rules which have had-little if any scientific foundation. An association of builders of hot-air furnaces has granted the Engineering Experiment Station of the University of Illinois certain funds of money to finance an investigation of these problems, the results of the investigation to be made public at its conclusion.

The problems of metal rolling are complex and have been studied in the past with difficulty because investigations must not interfere with production. The co-operative plan of equipping a full.size rolling mill at the Carnegie Institute of Technology equipped with special apparatus for varying conditions and making quantitative determination of different data exemplifies what is being done by another industry.

The Mellon Institute of Research of the University of Pittsbugh is unique and illustrates a development of research by funds contributed to a laboratory by individuals, corporations or industries for the solution of problems confronting them. The Institute was organized about 13 years ago by Dr. Robert Kennedy Duncan, and the contribution of funds for the support of the research was continued by each contributor for one or more years. The money so received served to pay the salary of the man or men on a special piece of research work and to pay for very special apparatus. The Institute houses the research, furnishes ordinary supplies and apparatus, affords library and consultation facilities and directs the work. The investigations are made for the donor and the results belong to him. At present the work is under the charge of a director, acting through two assistant directors in charge of the fellows on individual and multiple fellowships. In the Institute a method of developing complete unit experimental plants to study processes for certain donors has been used. In this way commercial processes have been developed from laboratory research in a way not done in many other research laboratories.

A list of co-operative efforts in research must mention the work of the laboratories of the Factory Mutual Fire Insurance Companies. The work of this association has covered many years, some of its bulletins being issued over 30 years ago.

Government Activities in Research.—The Bureau of Standards at Washington and Pittsburgh, the laboratory of the

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United States Geological Survey at Pittsburgh, the Food Laboratory and Forest Products Laboratory of the Department of Agriculture and the Naval Experiment Station at Annapolis, are a few of the Government activities interested in research.

At the Bureau of Standards research work is being done in physics, chemistry, metallurgy, manufacturing and engineering. There is hardly a branch of human endeavor which is not touched by this enormous research laboratory. In 1917-1918 there were over 1,400 employes connected with the bureau, and accounts aggregating more than $3,400,000 were handled. During this year the bureau issued 53 publications, and these may be obtained through correspondence.

The primary work of the bureau is the definition and fixing of standards of measurements, standard constants, standards of quality, standards of performance and standards of practice, and to do this they have divided the scientific and technical staff into a division of weights and measures, a division of heat and thermometry, an electrical division, an optical division, a chemical division, a materials division, an engineering research division, a metallurgical division, and a ceramic division. Each division is under a Chief of Division, and under him there are numerous experts and assistants. The bureau feels that its function is one of service to the nation, and it endeavors to aid all who apply for information or guidance.

The work of the Gage Section of the Bureau of Standards during the recent war activities must be remembered as of the greatest importance. This department undertook to regulate the gages used in the various manufacturing plants through its headquarters in Washington and its branches in the East and the Middle West. The Section has developed instruments for testing screw-thread gages for profile and pitch, instruments for end measurements, and, in fact, it is prepared to test any commercial gage or templet for accuracy. The Section has studied the salvaging of gages and is vitally interested in the problems of duplicate production.

The activities of the laboratories of the Geological Survey and the Department of Agriculture are devoted to their special fields of endeavor, and in each case scientists of training and experience are in charge of the research.

The U. S. Naval Experiment Station at Annapolis, Md., is used to study the apparatus and materials used by the U. S. Navy or certain Government bureaus. The work consists in making tests on these, and in addition researches regarding the general laws underlying the apparatus have been undertaken. The Station is well equipped with apparatus and an excellent staff. The work of the Station is for Government information, but frequent papers by members of the staff appear at times before various technical societies.

The Forest Products Laboratory of the United States Department of Agriculture at Madison, Wis., is devoted to problems relating to the applications of forest products.

The Watertown Arsenal is equipped for research in materials of engineering. The reports from this laboratory have been for years the source of many data on the strength of materials. The Philadelphia Navy Yard is equipped for research in fuel oils, while the Washington Navy Yard is equipped for testing ship models, propellers, airplanes and air propellers. The wind tunnels and testing-basin are of special merit.

The research activities of the American Society of Heating and Ventilating Engineers in connection with the Pittsburgh Laboratory of the United States Geological Survey is important and illustrates the activities of certain groups of scientists and engineers. This society plans to make researches regarding problems arising in its field of endeavor for the benefit of the profession and the public. In this project the expenditure of $20,000 per year for a number of years is proposed.

Commercial Research.—The private research laboratories of the country are primarily devoted to investigations of materials for commercial purposes, to check products or raw materials or to improve the product. Much of the work done by these laboratories is of the nature of inspection, but in many of them the commisions undertaken for clients have been of a true research nature, in finding the cause of defects, the methods of improving product and in some cases planning actual production methods or processes. Many of these laboratories have been in existence for almost a half a century; others have been developed in the last decade from a local need for such institutions.

The work of these private laboratories covers all fields of investigations and new equipment is obtained in many cases for special investigations. In some cases a laboratory has been specializing in problems of a definite character and its equipment for this work is expensive and complete.

Industrial Research. The last division of research activities is the one which undoubtedly represents the largest expenditure of money for operation, maintenance and equipment It is the one including the various laboratories of the manufacturing plants of the country.

The laboratories occupy two fields, one the examination, inspection and testing of raw materials or finished products, in which the laboratory is called in many cases the test laboratory; the other concerned in determining physical and chemical properties and constants of materials, the investigation, development or invention of new methods, processes of manufacture, or even of products and the testing of these new schemes, in which case the laboratory is termed the research laboratory. In many instances the test laboratories are devoted to routine work, while in others researches of importance are carried out in the test department. In some organizations the laboratory combines both features under one head.

One of the oldest and largest of the laboratories of the corporations is that of the Pennsylvania R. R. at Altoona, Pa. It was established in 1874, and at present its staff of workers is over 600 men, half of whom are engaged in inspection work. The expenses of this laboratory are about $500,000 per year, and the work of the department is the preparation of specifications for materials and supplies of the Pennsylvania System.

The locomotive testing plant, which was such a prominent part of the St. Louis Exposition, has been used at Altoona for further work in locomotive research. For studying problems on the road a dynamometer car is used by the laboratory. A unique part of their equipment is a laboratory car which may be sent to various parts of the system for the solution of local chemical problems or for other purposes.

The laboratories of the Westinghouse Electric & Manufacturing Co. at Pittsburgh, Pa., and of the General Electric Co. at Pittsfield, Harrison, Cleveland, Lynn and Schenectady, represent the large laboratories of the manufacturers of electric apparatus. In both of these companies the main research laboratories have forces of more than 100 men, and the budget of each amounts to $500,000 per year.

In the Schenectady plant of the General Electric Co. the department of tests is independent of the research laboratory. The reasearch laboratory is devoted to problems of the development of new materials, processes and apparatus, and, as its name indicates, its work is of a research nature.

Work in pure science, which at the inception has no commercial aim in view, is one of the activities of this laboratory and the publications of its results in the transactions of scientific societies gives evidence of such work. The results of these investigations in some cases have led to results of great commercial value—as in the case of the gas-filled lamp, which had its origin in a research on the laws governing the loss of heat from small wires coupled with an investigation on the evaporation of tungsten.

The research laboratory has as another of its functions the development of processes or of improved or new materials. The method of producing drawn tungsten wire, the production of insulating material, the improvement of transformer steel and the investigation of alloys represent certain of the problems of this laboratory. Here science has been applied for a definite commercial end. Another function of the laboratory is to make certain products for which there is but a limited demand. Thus the Coolidge X-ray tube, certain tungsten products and targets for X-ray tubes are manufactured in this laboratory.

The equipment of the laboratory is most complete for its activities. There are sixteen machines in its power plant giving power at different voltages and frequencies. Frequencies from 25 cycles to 2,000 cycles may be had and by transformers voltages as high as 200,000 or currents of 12,000 amperes may be obtained. The building is piped with city water, river water, illuminating gas, high-pressure hydrogen, low-pressure hydrogen, oxygen, high-pressure steam, compressed air and vacuum suction and vacuum cleaning. Distilled water is supplied to any room by gravity, and liquid air may also be obtained. Various kinds of gas and electric vacuum and arch furnaces are installed in one part of the building. A furnace is installed for argon purification. Various crushers, griuders, rolls, punches and a 60-ton hydraulic press are installed.

The illuminating laboratory, which is distinct from the research laboratory, is devoted to special problems in studying the best lighting units or methods of utilizing these units. The consulting engineering department laboratory, devoted to high-tension phenomena, the testing laboratory for materials, the standardization laboratory for instruments and the development of new instruments represent activities at Schenectady, which are devoted to research in their commercial routine duties. Many engineering departments are constantly making investigations which are of a research nature.

The work at the laboratories at Lynn and Pittsfield is largely applied to the production problems of these plants, and at Harrison and Cleveland the problems of lamp production are studied. The problems of the Westinghouse Co. are of a similar nature to those of the General Electric Co.

The research laboratory of the Eastman Kodak Co. represents the research activity of another manufacturing corporation. The staff of this laboratory consists of about 50 men, some 15 of whom are specialists. The budget amounts to more than $100,000. The work of the laboratory is devoted to physics, chemistry, to plant problems and new development. In this laboratory full-size apparatus is used at times in making research. As shown by the equipment of many laboratories, the study of complete processes in the laboratory on a commercial scale is one of the features of the times. The problems of this laboratory are organic, inorganic and colloidal chemistry, optics, color photography, film products and applications of general photography, chemical products and emulsions.

The laboratory of the National Lamp Association, now the Nela Park Laboratory at the National Lamp Works of the General Electric Co. at Cleveland, O., represents one of the best-known research institutions of this country. The research work of this laboratory is devoted to the physics, physiology and psychology of light, the production, utilization and efficiency of luminous energy. In this laboratory, with a staff of eight investigators of the highest ability directing the work, all kinds of illuminating problems are studied from every angle. The laboratory has a policy of sending out its experts to study local conditions, and in many cases investigators from other institutions come to this laboratory to carry on research. During the first eight years of its existence from 1908 the laboratory has produced 125 high-grade papers. These are abstracted by the authors and the abstracts published at intervals. In having abstracts made by the authors the important points of the researches are sure to be covered.

Still another agency which not only has been of utmost importance during the present war, but also in its continuance in the times of peace, will have a still greater influence on the developments in science and industry is the National Research Council

The National Research Council was under the chairmanship of Dr. George E. Hale, with three vice-chairmen, an executive secretary, a treasurer and two assistant secretaries. The executive board, under the chairmanship of Dr. John J. Carty, consisted of the officers of the Council, the chairman and vice-chairman of divisions and the chairman of sections of the General Relations Divisions, together with six elected members. The Divisions of the Council were as follows:

1. The Division of General Relations.
2. Military Division with its Research Information Service.
3. Division of Engineering.
4. Division of Physics, Mathematics, Astronomy and Geophysics.
5. Division of Chemistry and Chemical Technology.
6. Division of Geology and Geography.
7. Division of Medicine and Related Sciences.
8. Division of Agriculture, Botany, Forestry, Zoology and Fisheries.

Each division was divided into committees and sections, covering special features of the work. There were over one hundred scientists representing various technical and scientific societies, educational institutions, commercial laboratories and manufacturers.

The work accomplished by the council during the war has been so important and many of the investigations and researches which were not completed gave so much promise for the future that the council has been reorganized to continue in work for the furtherance of science and its applications.

Scale of Charges of Building Trades for Use of Small Tools

The following tabulation, reprinted from the monthly news letter of the Associated General Contractors of America shows the scale of charges for the use of small tools and appliances recognized by the Building Construction Employers' Association of Chicago:

	Wages.	Compensation and liability insurance.	Use of tools and appliances.	Overhead expenses and profit.	Total.
Carpenter foreman	$1.25	$0.07	$0.00	$0.18	$1.50
Carpenter journeyman	.80	.045	.105	.15	1.10
Carpenter laborer	.62½	.035	.04	.10	.80
Mason foreman	1.25	.07	.00	.18	1.50
Mason journeyman	.87½	.055	.10	.17	1.20
Mason laborer	.57½	.03	.045	.10	.75
Laborer foreman	.85	.04	.00	.11	1.00
Mason scaffold builders and mortarman	.65	.03	.12	.10	.90
Shoring foreman	1.00	.11	.00	.14	1.25
Shorers	.62½	.07	.10	.10	.90
Caisson foreman	1.25	.08	.00	.17	1.50
Caisson diggers	.77½	.055	.12	.13	1.08
Niggerheadmen	.70	.05	.10	.10	.95
Caisson riggers and laggers	.90	.06	.12	.17	1.25
Iron setter foreman, struct.	1.25	.25	.00	.20	1.70
Iron setter journeym'n, struct.	.87½	.12	.13	.17	1.30
Iron setter foreman, orna.	1.25	.095	.00	.15	1.50
Iron setter journeyman, orna.	.80	.06	.15	.14	1.15
Hoisting engineer	.87½	.05	.16	.16	1.25
Hoisting engineer, derrick work	.87½	.12	.185	.17	1.35
Steamfitter foreman	1.25	.05	.00	.20	1.50
Steamfitter journeyman	.87½	.0375	.15	.18	1.25
Steamfitter helper	.45	.0375	.10	.11	.70
Plumber foreman	1.25	.05	.00	.20	1.50
Plumber journeyman	.87½	.0375	.15	.18	1.25
Plumber laborer	.57½	.0375	.10	.18	.90
Gas fitter	.87½	.0375	.15	.18	.90
Drain layer	.68¾	.0375	.15	.15	1.05
Painter foreman	.90	.07	.00	.18	1.15
Painter journeyman	.75	.05	.10	.15	1.05
Decorator foreman	1.00	.07	.00	.18	1.25
Decorator journeyman	.80	.05	.10	.10	1.10
Comp. roofer foreman	1.00	.07	.00	.18	1.25
Comp. roofer journeyman	.77½	.055	.09	.13	1.05
Tile and slate roofer foreman	1.20	.07	.00	.23	1.50
Tile and slate roofer j'rneym'n	.80	.07	.18	.20	1.25
Tile and slate roofer helper	.65	.07	.12	.16	1.00
Sheet metal foreman	1.20	.07	.00	.23	1.50
Sheet metal journeyman	.80	.05	.20	.20	1.25
Sheet metal laborer	.65	.05	.13	.17	1.00
Sheet metal glazier	.77½	.07	.20	.20	1.25
Cement finisher foreman	1.10	.07	.00	.18	1.35
Cement finisher journeyman	.80	.05	.08	.12	1.05
Cement finisher helper	.625	.035	.05	.11	.85
Plasterer foreman	1.25	.00	.00	.00	1.50
Plasterer journeyman	.87½	.00	.00	.00	1.20
Plasterer laborer	.62½	.00	.00	.00	.96
Lather journeyman	.81½	.00	.00	.00	1.20
Pipe coverer foreman	1.25	.04	.00	.21	1.50
Pipe coverer journeyman	.81¼	.03¾	.14	.21	1.20
Pipe coverer helper	.50	.03	.12	.20	.85
Stack lining	.81¼	.03¾	.14	.21	1.20
Electrical foreman	1.25	.05	.00	.20	1.50
Electrical journeyman	.87½	.04	.14¾	.18¾	1.25
Stone cutters foreman	1.00	.02	.26	.22	1.50
Stone cutters journeyman	.81¼	.016	.26	.16	1.25
Stone cutters laborers	.57½	.03	.04½	.10	.75
Waterproofing	.80	.02	.105	.12	1.05
Concrete foreman	1.25	.07	.00	.18	1.50
Time keeper	.65	.02	.00	.08	.75
Concrete laborer	.57½	.035	.09	.10	.80
Tuckpointers and extension wall cleaners	.87½	.21	.045	.12	1.25

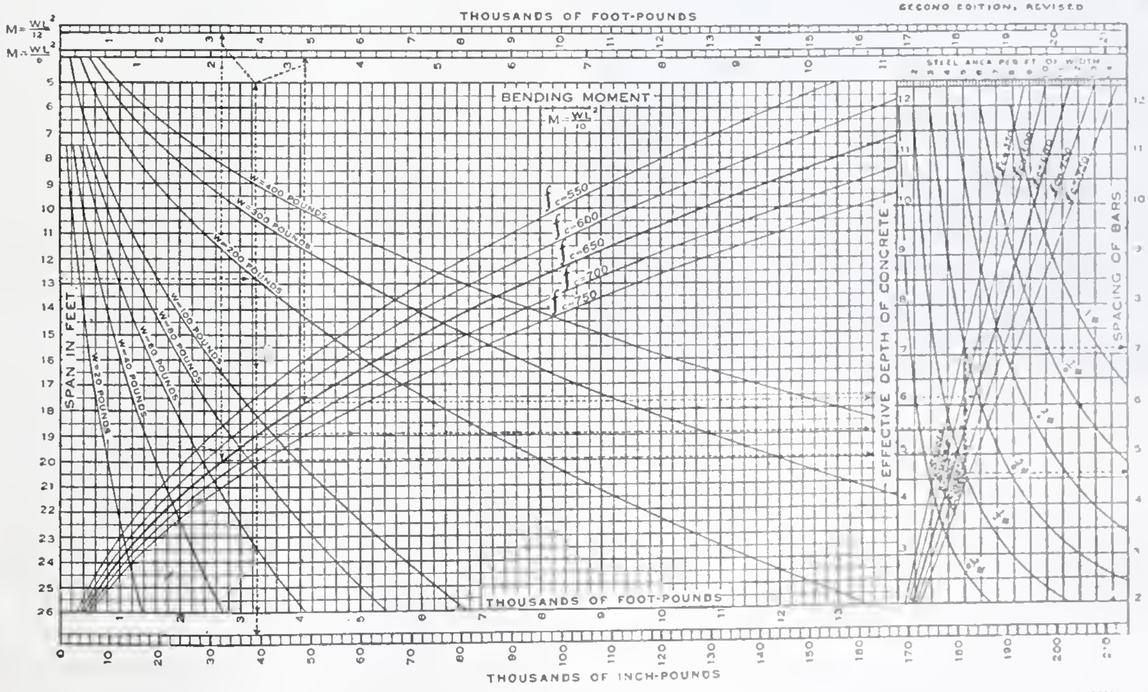
Bill for Relief of Treasury Department Building Contractors

A bill for reimbursing contractors for post offices and other Treasury Department structures for the increased construction costs due to war conditions was introduced in the House of Representatives on June 20. The text of the bill follows:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Treasury is hereby authorized and directed, under such regulations as he may prescribe, to receive fully itemized and verified claims and reimburse contractors and their sub-contractors, including material men, for the construction, improvement, special repair, equipment, or furnishing of post offices and other buildings or work under the supervision of the Treasury Department (as well as the United States courthouse in the District of Columbia and the approaches and retaining wall to the Lincoln Memorial in the District of Columbia) whose contracts were awarded or whose bids as thereafter accepted were mailed or delivered to the proper governmental authority prior to the entrance of the United States into the war with Germany, to-wit, April 6, 1917, and whose contracts have been or will be completed after said date, for increased costs thereafter arising from, due either, first, to increased cost of labor or materials, or, second, to delay on account of the action of the United States Priority Board or other governmental activities, or, third, to commandeering by the United States Government of plants or materials shown to the Secretary of the Treasury to have been sustained by them in the fulfillment of such contracts by reason of war conditions alone: Provided, That any sub-contractor may submit his claim though the contractor or to the Secretary of the Treasury. And the Secretary of the Treasury is hereby directed to submit from time to time estimates for appropriations to carry out the provisions of this Act: Provided further, That no claims for such reimbursement shall be paid unless filed with the Treasury Department within three months after the passage of this Act: And provided further, That in no case shall the contractor or subcontractor be reimbursed to an extent greater than is sufficient to cover his actual increased cost in fulfilling his contract or subcontract, exclusive of any and all profits to such contractor or sub-contractor; nor shall such reimbursement include any advances or payments made by the sureties of such contractor or sub-contractor in executing the work, but the surety on any contract coming within the provisions of this Act who, as surety, has completed, or may complete, the work of any defaulting contractor on any such contract, or who has furnished financial assistance to a failing contractor on any such contract whereby such contractor has been enabled to complete such contract, may file claim, within the period hereinbefore fixed, and be reimbursed in the manner hereinbefore provided for the increased cost due to the causes hereinbefore specified of the labor and material supplied in so completing any such contract, or for the increased cost of the labor and material paid for from funds so furnished by such surety: And provided further, That the Secretary of the Treasury shall report to Congress at the beginning of each session thereof the amount of each expenditure and the facts on which the same is based.

Computation Diagram for Reinforced Concrete Work

A diagram that has proved very useful for computation work either in designing or in reviewing plans for reinforced concrete construction is illustrated. The chart has been used extensively in the U. S. Quartermaster's Department for several years. During the past 2 years it is safe to say that it has been employed in the computation work for several hundred reinforced concrete structures. The diagram was devised by Maj. L. S. Doten, 1714 Euclid St., N. W., Washington, D. C.



16.000 LBS. STRESS IN STEEL.

Computation Diagram for Reinforced Concrete Floor Slabs, Retaining Walls, Etc.

Sixty-five Per Cent of Fabricating Shops Contracted for in June.—The records of the Bridge Builders & Structural Society as collected, by its secretary, show that during the month of June, 1919, 65 per cent of the entire capacity of the bridge and structural shops of the country was contracted for.

Tests of Bearing Power of Shale

In connection with the preliminary work for the Bloor St viaduct at Toronto, Ont., investigations were made of the bearing value of the shale on which several piers were to rest. These tests are described by Mr. Thomas Taylor in the Journal of the Engineering Institute of Canada, from which this note is taken.

In the first place, laboratory tests were made on specimens taken from the quarry of the Don Valley Brick Works. These were selected from the softest strata in the quarry face and were considered to be representative of the softest material beneath the piers. Owing to the laminated structure of the shale and its tendency to break down when exposed to air it was impossible to get specimens greater than 2-in. cubes; and of those obtained, only one could be considered perfect. When tested in compression this specimen failed at 1,500 lb. per square inch, while the worst specimen sustained over 500 lb. per square inch, the others giving intermediate values.

As such shale in place has important advantages over small specimens, viz.: exclusion from air and lateral support, it was decided to secure information as to its carrying capacity when undisturbed. In the excavation for an addition to the John St. pumping station shale was exposed which was apparently identical in character with that obtained by the core drill in the borings for the Bloor St. viaduct. With the co-operation of the Waterworks Section of the Department of Works loading tests were made there under favorable conditions, the layers being undisturbed and the surface being covered with water.

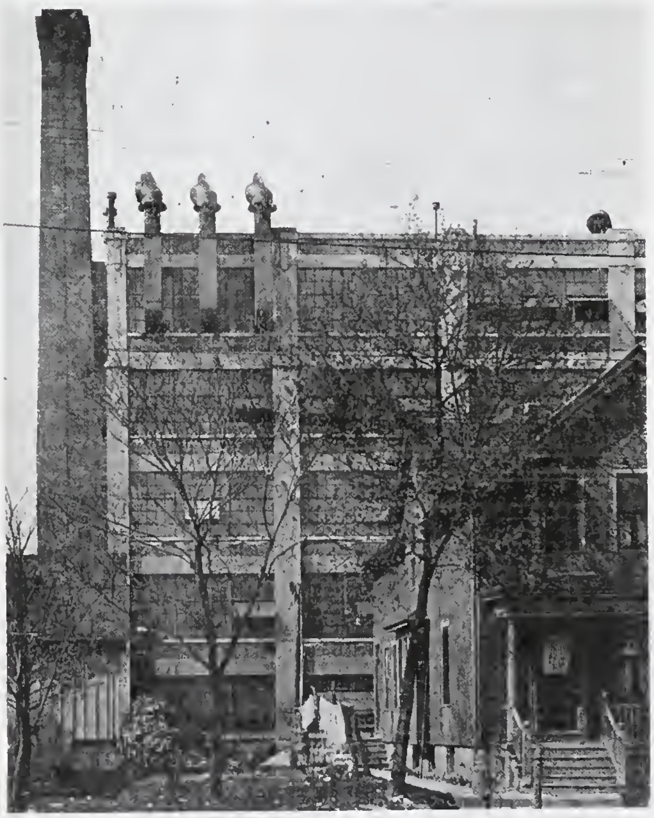
As heavy loads were required to give appreciable settlements, a special platfrom of steel shapes was constructed. After several strata were removed exposing the softer shale, the latter was carefully leveled off for bearing and the platform erected with the foot of the mast resting on a casting 8⅛ in. square, while the top was braced against overturning. Special care was taken to determine settlement and to check results.

On Dec. 10, 1913, pig iron was gradually loaded on the platform from 1:30 to 5:45 p. m., the total load being 28,670 lb., causing a gradual settlement of 0.09 in. during that time and a further settlement of 0.09 in. before 8:15 on the following morning. Additional pig iron was then added until 2:45 p. m., when the total load was 65,043 lb. or 986 lb. per square inch. The settlement during this period of loading was 0.12 in. and in the succeeding 24 hours a further settlement of 0.15 in. took place. Readings were taken on Dec. 13, at 11 a. m., and Dec. 15, at 9 a. m., neither of which showed additional settlement.

On removal of the platform the shale beneath was found to be so crushed that it could not be rubbed to a paste in the hand. This effect extended for less than 3 in. in depth and the shale immediately around the loaded area showed no sign of injury. To determine the effect on the shale when loaded less heavily the platform was set up in another place, a few feet from the first location. On Dec. 20, the loading was commenced but was discontinued at noon. The total load was then 11,320 lb. or 17.2 lb. per square inch. On Dec. 23, at 9:30 a. m., the settlement observed was 0.06 in. By noon the total load was increased to 26,540 lb. or 402 lb. per square inch. During this time a settlement of 0.02 inches was noted. On Dec. 26, no further settlement could be detected and the load was removed. On removal of the platform no injury to the shale was noticeable.

Ventilating Installation With Outside Flues

An out of the ordinary method of installing a ventilating system was employed for the brass finishing room of the factory of Briggs & Stratton, Milwaukee, manufacturers of automobile specialties. The factory is of modern construction, and light and airy, but one department, the brass finishing room, developed difficulties in the way of ventilation. The acid fumes could not be disposed of by ordinary methods. To remedy this trouble A. C. Goethal, a metal worker, of Milwaukee, installed Alpina syphon revolving ventilators. The ventilators themselves were, of course, installed on the roof, to get the circulating air currents which, by passing over and through them, create the vacuum, and cause their syphonating power. But the flues which were to bring this syphonating influence of suction to bear on the offensive fumes and odors from the enameling sprayer, and carry them away, had to be placed where they would do the most good. In this particular instance the flues were extended down the sides of the building and into the brass finishing department at the window sills. This brought the mouth of the flue close to where the fumes were created.


Showing Method of Installing Ventilation Flues.

Another Column Formula

In an article, "Strength of Various Long Columns" in the Canadian Engineer, William Jackson, Assistant Engineer, Department Railways and Canals, Edmonton, Alta., attempts to modify Enler's old formula and derive a new one that may be used in designing columns. C. P. Buchanan's tests of pin connected columns as given on page 625, Engineering News of Dec. 26, 1907, and tests made by the American Society of Civil Engineers are used to check up the formula, and some interesting conclusions are made.

Whether the proposed formula is workable may be judged from the formula itself. As given it has the general form:

$$\frac{l}{r} = \sqrt{\frac{CE\ (f-p)}{p\ (f-kp)}}$$

where $l =$ length.

$r =$ radius of gyration

$f =$ stress on outside fiber

$p = \frac{P}{A} =$ safe load divided by area of cross-section

$E =$ modulus of elasticity

$C =$ constant depending on condition of ends of columns ranging from π^2 to $4\pi^2$ or say 10 to 40.

$k =$ another constant depending on fact that E on one side of column differs from E on the other side, due to "minor defects," and is assumed to be equal to 0.75.

When $C = \pi^2$ and $k = 1$ the formula comes down to the usual shape of Enler's formula

$$\left(\frac{l}{r}\right)^2 = \frac{\pi^2 E}{p} \text{ for pin-end columns}$$

The transition stage between our old friend $f = 16000 - 70 \frac{l}{r}$ and something better is indeed a trying one.

Personals

O'Neil & Kingsberry have opened offices at 726 New York Block, Seattle, Wash., and will engage in a general contracting business.

George Schroeder and Conrad Schroeder have entered into a partnership and will engage in building contracting, with offices at Amherst, O.

Frank E. Curley, Mrs. Ruthrauff and Byrd Brooks, all of Tucson, Ariz., have organized the West Coast Construction Co. and will engage in a general engineering and contracting business.

Charles F. Shannon has been elected president of the Shannon Construction Co. of Akron, O. The company will carry out an extensive housing project at Akron for Firestone Rubber Co.

Rudolph P. Miller, formerly superintendent of building for Manhattan; and chairman of the board of standards and appeals, and Geo. E. Strehan, formerly assistant engineer in the bureau of buildings and the board of standards and appeals, of New York City, have become associated in the general practice of engineering at 112 W. 42nd St., New York City.

Raymond R. Marsden, of Wilmington, Del., has been elected professor of civil engineering in the Thayer School of Civil Engineering at Dartmouth College. He is a graduate of Dartmouth, 1908, and Thayer School, 1909. From 1909 to 1910 he was an instructor there. Since his graduation he has been a resident engineer in charge of construction of pulp and paper mills and hydraulic installations at Grand Mere, Quebec; Hawkesbury, Ont., and Wilmington, Del., in the latter place investigating high explosive plants and improvements in such plant sites.

Captain Merlin L. Dappert of the 130th Infantry, 33rd Division (Prairie), has returned from France and will resume his work in engineering, being associated with his father, J. W. Dappert, of Taylorville, Ill. Captain Dappert has been overseas a year, participating in the Somme offensive, the Meuse-Argonne offensive, and was in the Army of Occupation in Luxembourg. Four other sons of Mr. Dappert also were in war service. Lieut. J. Ivan Dappert was killed in action near Albert, France, Aug. 11, 1918. He was with Company K, 132d Infantry, and was killed by machine gun fine. Lieut. John V. Dappert, 130th Infantry, is now at the Fort Sheridan Hospital undergoing treatment for his eyes. He was severely gassed in the Meuse-Argonne offensive, refused to leave the fight to go to the hospital and was not evacuated until after the armistice was signed. He has been in the hospital ever since, but his eyes are now improving and he expects to receive his discharge papers before long. Lieut. Anselmo F. Dappert, Heavy Tank Corps, landed at New York City and is now at Camp Mills, New Jersey, awaiting discharge. Sergt. Boyd H. Dappert, Company D, 306th Engineers, is still in France, but expects to sail for the states in August. He will resume his work as county surveyor of Christian County, Illinois, upon his return to Taylorville. A daughter, Lucy C. Dappert, was in the War Risk Insurance Department at Washington during the war.

Industrial Notes

The Chicago Pneumatic Tool Co. has removed its Minneapolis office from the Metropolitan Bank Building to 5th Ave. and 5th St., South, Minneapolis, Minn.

Acting under instructions from the Director of Purchase, Storage and Traffic Division of the War Department a list of citations has been prepared for certificates of merit for distinguished service in manufacturing material. The following is the citation for the Canton Culvert & Silo Co.: "The work performed by this company in the fulfillment of its contracts covering engineer material was highly satisfactory and worthy of commendation."

At the time the armistice was signed the company had on hand orders from the Government, filled and unfilled, for over $2,000,000 worth of nestable culverts, shelters, etc.

Foreign Engineering Review Issue

ENGINEERING AND CONTRACTING

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HALBERT P. GILLETTE, *President and Editor* LEWIS S. LOUER, *Vice-President and General Manager*
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Cleveland Office: Room 413 Engineers' Bldg., LEO EHLBERT, *Manager*

The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field if subscribed for as a weekly at $3.00 a year; but any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year (or any two monthly issues at $1.50 a year) and the 4 special quarterly issues will be sent without extra charge. Three of these special quarterly issues relate entirely to foreign engineering and construction practice, and the fourth is our annual "New Equipment Issue." The *articles* in the first two issues of each month (1st and 2nd Wednesdays) completely cover the municipal engineering and contracting field. The *articles* in the first and last issues of each month (1st and 4th Wednesdays) completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and last issues of each month (3rd and 4th Wednesdays) completely cover steam and electric railway location, design and construction. See the "mast head" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging (c) Quarries and Pits
(b) Rivers and Canals (d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings (c) Harbor Structures
(b) Bridges (d) Miscellaneous Structures
(e) Properties of Materials

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Volume LII. CHICAGO, ILL., JULY 30, 1919. Number 5.

Our Foreign Engineering Review Issue

Four months of this year have five Wednesdays and on each of these "5th Wednesdays," Engineering and Contracting is published as a large special issue. One of the special quarterly issues is devoted entirely to brief descriptions of new equipment in the civil engineering and contracting fields. This was published on Jan. 31 last. The other special issues are given up to civil engineering developments and improvements in foreign countries.

American engineers are justly proud of their own engineering achievements, but they should not let their national pride deter them from studying carefully the engineering works of other nations. Relatively few American civil engineers and contractors have access to foreign engineering periodicals. Hence our decision to publish these large special issues, giving comprehensive summaries of the most useful information to be found in foreign civil engineering periodicals and technical society transactions.

Results of State Railway Operation in Germany

From The Engineer, June 13, 1919.

One of the leading problems of the present time relates to the question of the nationalization of railways or the conservation of the railway system as private property. When discussions arise concerning the advisability or otherwise of converting the railways into state undertakings, the advocates of absorption by the nation refer in particular to the railways in Germany as an example of the profitable operation of this method of transport by the Government, and they contend that the financial results of state ownership and working there are, or have been, superior to those obtained by the privately owned railways in the United Kingdom. But can this contention be sustained, or confirmed in the light of the actual experience of that country? At the present moment the authorities in Germany, as represented by those members of the National Assembly at Weimar who hold the reins of government, are endeavoring to bring about a unification of the whole of the railway system throughout the country. In this connection it is well to recall the fact that the Prussian State Railways are operated in conjunction with those of Hesse under the title of the Prussian-Hessian Working Community, whilst the Bavarian, Saxony, Wurttemberg, and Baden State Railways are worked independently by their respective states, leaving out of consideration the less important systems of Oldenburg and Mecklenburg as well as those of the Reichsland or Alsace-Lorraine. It is now hoped to amalgamate the railways into a single unit, and if the scheme is brought to maturity the smaller networks would have to follow the example. The combined system of the Prussian-Hessian railways represents—or represented before the war—a total mileage equivalent approximately to that of the railways in the United Kingdom. It is not, however, with the unification or amalgamation of the entire German railway network that we are concerned at the present time, but with the financial results of the working of the railways, and the Prussian-Hessian system is that which is most appropriate to consider in this connection.

It is quite an easy matter for erroneous conclusions to be drawn from the railway returns published in Germany. The mistake apparently arises, or has arisen, from the confusion of the term gross surplus with that of net profits. Let us take, for instance, the Prussian-Hessian railways as representing the most extensive system in that country, and concerning which the actual results have just been issued for the series of years from 1913-14, whilst the Budget estimates are available for 1917-18, 1918-19, and 1919-20. The financial year begins on April 1st and the return for 1913-14 therefore represents the last year of peace, which was a favorable year for the railways. According to the official figures the working expenses of the Prussian-Hessian combined railway system formed 69.2 per cent. of the gross receipts in 1913-14, and the gross surplus—gross receipts less working expenses

—amounted to 6.39 per cent of the average capital invested in that year. The ratio of working expenses to gross receipts increased to 79.7 per cent in 1914-15, but declined to 71.1 per cent. in 1915-16, and reached 71.7 per cent. in 1916-17. On the other hand, the gross surplus receded to 3.59 per cent. of the average capital invested in 1914-15, but rose to 5.57 per cent. in 1915-16, and to 6.24 per cent. in 1916-17. It is this percentage of the gross surplus which has often been incorrectly assumed to represent net profits. At the same time, it is only fair to say that the gross surplus has frequently been referred to even in Germany as net profits. Let us see what became of the gross surplus in the normal year of 1913-14. One-third of the amount was placed to various reserve funds, including an equalization fund, a fund for complementary and extension works, and a redemption fund at the rate of 0.6 per cent. of the railway debt on a capital expenditure on works of repair, maintenance, and renewals into sterling— of £615,750,000 in 1913-14. The fund for complementary and extension works must necessarily include pexpenditure on works of repair, maintenance, and renewals and provision for depreciation. These appropriations reduce the percentage of the gross surplus of 6.39 per cent. to net profits of 4.25 per cent., and the amount represented by this percentage was applied to the payment of interest charges on the railway debt, whilst the balance was allotted to the credit of the Prussian Treasury for national purposes.

The advocates of nationalization may possibly contend that net prices of 4.25 per cent. on a railway system equivalent in extent to that in the United Kingdom show that the Prussian-Hessian railways yielded a better return on the capital than the average return on British railways in peace times, and also furnished a substantial sum in aid of the Prussian national exchequer. If this argument be adduced a very definite answer is forthcoming. The capital outlay on the Prussian-Hessian railways was only approximately one-half of that which the British railway companies were compelled to expend owing to rapacious landowners and speculators, parliamentary restrictions and other burdens. If, however, the Prussian-Hessian railway system had suffered from similar causes and the capital expenditure for the identical mileage had been equal to that of the British railways, the German railways in question would not only be unable to yield a penny per annum to the Treasury, but the net sum available would be insufficient to defray the interest charges on the debt. This would have been specially the case in the normal year of 1913-14, and is a very important fact to be borne in mind in the case of railways which were financed by Prussian Consols at 3 per cent. The redemption of debt at the rate of 0.6 per cent. is not a matter of any particular significance when it is remembered that the total sum annually applied to this purpose has been nullified by the constant increase in the railway debt, year in and year out, by an amount of from ten to twelve times the annual reduction; in other words, the debt never decreases, but is always growing on a railway system which probably has no parallel in the world for the abundance and richness of the goods and mineral traffic which it has to transport.

Road Locomotives and Heavy Motor Cars

From Engineering, May 2, 1919.

The report of the Departmental Committee appointed by the Local Government Board in March, 1915, to consider the law and regulations relating to the construction and use of road locomotives and heavy motor cars in Great Britain, has just been published. The committee was appointed on account of complaints made by road authorities as to damage caused to roads by heavy mechanically-propelled traffic, and its object was to examine into these complaints and to advise as to the steps necessary to be taken with regard to the damage. The length of time that has elapsed between the appointment of the committee and the presentation of its report is, of course, due to conditions arising out of the war, so that no criticism can reasonably be raised on that score. The committee have examined a large number of witnesses representing various road authorities, makers and users of road locomotives and heavy motor cars, and also representatives of agricultural interests. The views of all parties seem to have been carefully considered, and the suggested alterations to the law and regulations, although by no means drastic, appear likely to reduce road wear without imposing undue restrictions on the industries concerned.

That widespread and extensive damage has been done by the class of traffic being considered appears to have been established without doubt by the evidence before the committee, but this damage is largely due to the traffic using roads quite unsuitable for it. In the case of roads paved with setts, wood, or asphalt, on concrete foundations, the evidence seems to indicate that such damage as occurs is caused mainly by iron and steel-tired traffic. Rubber-tired traffic, even when traveling at high speeds on such roads, appears to have no serious effect provided that the surface is kept reasonably smooth and level. As regards the modern method of road construction in which bituminous materials are used as a binder or matrix, the evidence is not so conclusive, but there appears to be no doubt that such roads, if properly constructed and maintained, are capable of carrying a considerable amount of heavy traffic without damage. With the commoner form of water-bound macadam road the committee are of the opinion that the damage is mainly due to rubber-tired traffic.

The report deals first with road locomotives, considering separately the questions of weight, construction and speed. With regard to the first point the committee do not consider it necessary to reduce the weight of traction engines from the existing maximum of 14 tons, and, in the case of engines fitted with Boulton wood block driving wheels, they suggest that the maximum should be increased to 18 tons. Weight, however, is to be more clearly defined, and the suggestion is that the term should include all parts necessary to, or ordinarily used with, the engine as employed on the road, excepting water, fuel and loose tools and equipment. Licensing authorities, it is thought, should ascertain the correct weight by actually weighing the engine. One recommendation with regard to the wheels of road locomotives is that the distinction made by the Act of 1878 between a locomotive drawing a wagon and one not so employed should be abolished. Another is that the width of the tire of each wheel, whether steering or driving, should be at least 5 in., and the width of tires for driving wheels should be such as to comply with Section 28 (Subsection 2) of the 1878 Act. If bands are used on steering wheels their widths must not be less than 5 in. The committee, although they have been satisfied that serious damage to roads has been caused by cross-barred driving wheels, do not consider it possible to prohibit their use without seriously reducing the hauling capacity of traction engines, or restricting the use of agricultural locomotives. To diminish the damage as much as possible, the cross-bars, it is suggested, should be arranged so that the aggregate extent of the cross-bar (or bars), in the course of a straight line drawn horizontally across the circumference of the wheel, should be nowhere less than half the width of the tire. They also consider that the use of cross-bars should be prohibited on wheels less than 4½ ft. in diameter. The committee consider it desirable to require road locomotives to be mounted on springs, except in the cases of road rollers and ploughing engines, but it may be noted that existing locomotives are exempted from all the above-mentioned recommendations.

The existing provisions with regard to wagons drawn by locomotives are admittedly antiquated and unsatisfactory, and a number of alterations to these are recommended. These recommendations relate to the marking of unladen weights, forms and widths of tires, and diameters of wheels. Springs are not insisted upon, but to encourage their use as much as possible it is proposed to allow additional weights on spring-mounted wagons, or to permit the use of smaller wheels for a given loading, when springs are employed. It is also recommended that a highway authority should be notified in advance of the passage over a road in its area of a traction engine hauling a wagon carrying a single article exceeding 16 tons in weight. No alteration is proposed in the existing speed limit for road locomotives of 4 m.p.h in the country, but in towns it is thought that undue congestion is caused by the present speed limit of 2 m.p.h. The committee therefore recommend that the latter be increased to 3 m.p.h.

Owing to the many different types of vehicles which come under the heading of heavy motor cars, and to the great variety of uses to which they are put, the framing of regulations for their construction and use is naturally more difficult than is the case with road locomotives. The enormous development in the use of such vehicles, however, renders a solution of the problems involved imperative, and, as the committee fully realizes, the convenience of a very large section of the general public is greatly affected by the decisions made. The committee have, of necessity, considered the question mainly from the point of view of damage to roads, and we share with them the hope that the financial burdens will ultimately fall upon the right shoulders. We also agree with their view that the adjustment of this burden is the crux of the whole question of mechanically-propelled traffic.

Heavy motor cars are dealt with in a manner similar to that adopted for road locomotives, that is to say the questions of weight, construction and speed are treated separately. With regard to weight, it is proposed to increase the maximum allowed for the motor car alone, from 5 tons to 6 tons unladen, and the combined unladen weight of car and trailer from 6½ tons to 8 tons. The unladen weight is to include all parts necessary to, or ordinarily used with, the car when working on the road, but is not to include water, fuel or accumulators (other than boilers) used for propulsion, or loose tools or equipment. It is not considered necessary to alter the existing maximum laden weight of 12 tons for the car, or 8 tons for any axle of the car, or 4 tons for any axle of the trailer, but some measures are proposed for securing stricter compliance with limitations on weight. With regard to the construction of wheels the committee recommend that in the case of wheels fitted with iron, steel or other hard tires, the minimum diameter should be raised from 2 ft. to 2 ft. 9 in., and that, for axle weights exceeding 4 tons, wheels of the following diameters should be used:

	Ft.	In.
Axle weights exceeding 4 tons but not exceeding 5 tons..	3	3
Axle weights exceeding 5 tons but not exceeding 6 tons..	3	6
Axle weights exceeding 6 tons	4	0

The edges of the tires of such wheels should be rounded and not bevelled, but in other respects the existing regulations should not be altered. For rubber-tired wheels the proposed minimum diameter is 2 ft. 6 in., but no regulation is proposed with regard to the size or shape of the tire itself. Neither is it considered necessary to prescribe a scale of minimum diameters proportionate to axle weights in the case of wheels fitted with rubber tires.

There are, at present, no regulations restricting the overall length of vehicles length of wheel base, or amount of overhang of the body behind the driving axle, and, as a consequence of this, the tendency of makers has been to bring the rear axle as far forward as possible. This feature, although giving a better drive, has the effect, in the opinion of the committee, of damaging the roads to a considerable extent. It, of course, throws an undue proportion of the total weight of the vehicle upon the driving axle, and is partly responsible for the contraventions of the existing regulations as to axle weight which have occurred in the past. It also increases the swinging motion of the rear of the vehicle, and so augments the force of the impact on the road surface when the latter is at all uneven. To diminish this source of trouble it is proposed to limit the maximum overall length of a heavy motor car to 26 ft., and to fix the amount of overhang behind the rear axle to a quantity not exceeding seven--twenty-fourths of the overall length of the car. It is not proposed to make any definite regulation as to the length of wheel base. London motor omnibuses, the committee think, should be required to conform to the above-mentioned rule with regard to overhang, even if the necessary structural alterations involve some increase in weight, but the amended regulations with regard to wheel diameters, length of vehicle, and amount of overhang, will not be made to apply to any class of heavy motor car in use at the time the new regulations come into force; neither is it proposed to reduce the load which such cars would otherwise be permitted to carry. The committee also propose to exempt motor rollers from compliance with any requirement as to the construction of wheels or tires.

With regard to the use of trailers it is proposed to retain the existing law, which permits the use of only one trailer behind a heavy motor car, and if more than one trailer is used the motor tractor is to be treated, in law, as a locomotive. It is proposed to limit the aggregate of the marked axle weights of a trailer to 8 tons, and to raise the minimum diameters of wheels of trailers exceeding 1 ton in weight unladen from 2 ft., as at present, to 2 ft. 6 in. when iron or steel tires are employed; the edges of the tires are to be rounded. No minimum diameter is to be fixed for trailer wheels with rubber tires. It is not proposed to permit trailers carrying passengers or luggage to be drawn by passenger-carrying vehicles.

The question of speed limits for heavy motor traffic has been gone into very fully by the committee. Proposals were made by representatives of the Metropolitan Borough Councils to reduce the speeds of motor omnibuses from 12 m.p.h. to 10 m.p.h., and of other rubber-tired traffic from 8 m.p.h. and 12 m.p.h. to 5 m.p.h. and 8 m.p.h. respectively. The London General Omnibus Company, however, wished the limit for motor 'buses to be raised to 16 m.p.h. These proposals, and others made on behalf of motor users, were very carefully considered, and as a result of their deliberations, the committee recommend that the present regulations be retained subject to the amendments that the speed of heavy motor cars with iron or steel tires shall in no case exceed 5 m.p.h., and that, when drawing a trailer, the maximum speed shall be raised from 5 m.p.h. to 8 m.p.h., provided that both motor and trailer are fitted with rubber tires.

The report also deals with the restriction of heavy traffic on unsuitable roads, recommending that motor omnibus, and similar passenger traffic, should be brought under special regulations in this respect. It is also proposed to confer powers on the Local Government Board, and the road authorities, to regulate through traffic of heavy motor vehicles so as to ensure, as far as possible, that such traffic shall use roads suitably constructed to carry it. County councils, it is considered, should be given power to regulate traffic on a road under repair, and to divert the traffic on to another road. The committee has also considered a number of special questions, and it may be of interest to mention their recommendations in respect to some of them. In place of the existing provisions regarding the emission of smoke, or visible vapor, from locomotives or motor cars on public highways, it is proposed to make it an offense to cause, or permit, the emission of such smoke or vapor in such quantity as to be a nuisance or danger to the public. The by-law requiring the provision of means of communication between the rear wagon of a train of wagons and the locomotive driver is to be made a statutory requirement, and heavy motor cars will be required to carry a mirror to enable the driver to see overtaking traffic. Motor users will also be glad to note that the committee recommend that "the existing law should be amended so as to provide more effective measures for securing the strengthening and improvement of bridges which do not meet the requirements of heavy self-propelled traffic, and to ensure the removal, and prevent the imposition, of unnecessary restrictions upon the use of bridges by such traffic." It is also suggested that public funds should be made available to encourage the design and construction of vehicles calculated to cause less damage to roads. Facilities would be given for trials and demonstrations of such vehicles to be made on public roads, although the vehicles could not be ordinarily employed without breach of the law.

Powered and Colloidal Fuels

From The Engineer, May 9, 1919.

The war taught people how to economize in a great number of things, but in none more than in fuel. Economy of fuels has always been carefully studied by engineers, but until recent years, not because there was any recognition of the fact that the supplies were exhaustible, but solely because the cost of fuel was an important item in the total cost of power.

Of recent developments in fuel economy, none are more promising, none more interesting than the extension of the use of powdered coal and the introduction of colloidal fuel. Coal dust fuel is, of course, not new; it has been burnt for many years with perfect success in cement kilns, but, although many attempts have been made to employ it for steam raising, it has hitherto met with very limited adoption. Colloidal fuel—a bad name for a good product—is, we believe, quite new. It is an American wartime invention, and is intended not so much to conserve American coal supplies as to prevent the exhaustion of the oil wells, which appears to be the more imminent. It is defined in the fewest words as a mixture of coal dust and oil. Everyone knows by experience that given sufficient time particles of a higher specific gravity will subside in a liquid of lower specific gravity, unless they are comminuted to an extremely high degree of fineness. Graphite, for example, may be reduced to such extreme fineness that it will remain indefinitely in suspension in pure water. The coal dust employed in colloidal fuel is not necessarily extremely fine, and the problem faced by the inventor, Mr. Lindon W. Bates, was to effect the permanent suspension of relatively large particles in oil. By the introduction in small quantities of some material—the nature of which is not revealed—this end has been secured, and it is reported that even slow agitation, as, for example, that of the rolling of a ship, does not cause the particles of coal to coalesce into pieces heavy enough to sink. Hence, it would appear that a permanent fuel of a useful kind has been evolved. It has the advantage over plain coal dust that it can be fired through oil jets with quite a moderate air pressure, whereas pulverized fuel requires burners of a special kind. In another important respect also it is better. The explosive qualities of coal dust are well known, and rigid regulations have to be observed in handling it. Colloidal fuel is no more dangerous than the oil itself, and can be handled, stored, pumped and bunkered in exactly the same way. With regard to its evaporative power and its economic use, we need say no more now than that they are satisfactory. Unfortunately, it must remain an American product—unless the Derbyshire oilfields provide a suitable oil in sufficient quantity—and British engineers must face the plain coal dust problem. A notable advance in this direction has been made by Mr. J. G. Robinson, whose pulverized fuel locomotive was described fully in our issue of April 25th. Here again the credit for the introduction must be given to American engineers, for locomotives fired with coal dust have been at work for many months in the United States. Whilst Mr. Robinson appears to have effected some simplification, it must be admitted that even his engine is more complex than one could desire, involving as it does two little engines, a good deal of gearing and a fan, for conveying the coal from the tender and blowing it into the furnace. British engineers have always favored simplicity of locomotive design, and this complexity is likely to make them look askance at coal dust, but if the fuel justifies itself on the grounds of all-round economy, progressive invention will certainly reduce the present number of parts. It is, for example, conceivable that the blower may be replaced by a high temperature steam jet. Mr. Robinson has been hampered, just as American designers have been hampered, by the desire to change as little as possible the design of engine and tender. To get the best results, it may be necessary to break away boldly from traditional standards, and to design both boiler and tender on new lines. Mr. Robinson, it will be observed, has found it necessary to place his burners lower than he at first thought necessary, in order to increase his combustion space. He has had also to introduce two arches instead of one. These facts lead us to the conclusion that the present form of box is only a makeshift when fitted for coal-dust firing, and that a totally different form of box, possibly a long and narrow one, or even a cylindrical box, would be more suitable for the conditions. We trust that before their enterprise is sapped by the nationalization of their factories, other locomotive engineers of our great lines will pursue the problem.

It will be seen from what we have said that engineers are tackling the question of fuel economy in a very practical way. Recognizing that the fuels to which they are accustomed have reached a price which alters all the old standards, they are endeavoring to employ a relatively cheap material. Efforts of the kind have, only too often, in the past led to eventual disappointment. The course of events has usually been that as soon as a cheap commodity met with a demand its price was raised either by the action of the natural laws of supply or by the creation of "corners." Real economies are constantly checked by the rise in price of by-products. Coal dust may be regarded as a by-product of the pits, and it is worth considering as an economic problem if it is not possible to fix its price as a permanent proportion of lump coal, so that its employment may be encouraged.

German Regulations for Reinforced Concrete Flat Roofs.—The new German regulations of November, 1918, for flat roofs, according to Beton u. Eisen of March 5, 1919, limit the maximum span to 21 ft. 4 in., with a minimum thickness of 4 in. for loaded roofs, and 2⅜ in. for unloaded roofs. Additional thickness must be provided when subject to vibrations. The rules refer only to reinforced flat roofs, but special rules are given for plain concrete slabs intended for roofs of dwelling houses and factories. Tests must be carried out under Government supervision.

Waterworks Engineers and Legislation

From The Surveyor, June 30, 1919.

It is certainly necessary that we should grasp the fact that the purchasing power of money has declined all over the world, and that it has declined permanently. A salary that has not been increased since pre-war times leaves its recipient in exactly the same position as that of a man whose salary is reduced by one-half, and if we have to supply materials at pre-war prices we shall lose by the transaction. The same principle applies to the supply of water; the price of wages, fuel and materials having risen, it follows that a similar increase in charges is inevitable. Nothing is more certain than that pre-war prices and costs will never again be realized, and the president of the Institution of Water Engineers, Mr. Alford B. E. Blackburn, engineer and general manager to the Sunderland and South Shields Water Co., does well to bring the matter forward prominently in his able presidential address. It must be obvious to any thinking person that no class of undertakings has been less able to cover its increased cost of operation than waterworks. Not only have the expenses increased, but the Government restrictions are such that in many cases water authorities will be unable to produce a proper supply, except at a loss, or, in the case of the water companies, by reducing the dividends to such a point that nobody will invest money in future undertakings. The matter is the more serious in that this state of affairs follows a period of over four years wherein all works, except those of the utmost urgency, have been postponed. We are faced with urgent needs and increased demands for supplies, while health statistics show the need for purer water, also with the fact that the majority of our rural districts are still without proper supplies. Mr. Blackburn asks the pertinent question, How much water is still left for future use, and what are the needs of the country for further supplies? "On these vital matters there is an almost entire absence of information." Our principal watersheds have been appropriated by powerful corporations to the detriment of smaller communities. The law gives commercial and private interests undisturbed and unrestricted power to obtain underground water, while authorities who supply our large populations with a prime necessity of life are bound by severe restrictions. Thus, while it permits water authorities to spend large sums of public money in obtaining underground water, it allows commercial undertakings to sink wells at the expense of the public supply. The president justly points out that the position is absurd. Further, the Government which guaranteed pre-war rates of dividend to railway stockholders prevents the holders of water companies' stock increasing their rates to such a degree as to allow of their drawing more than three-quarters of their pre-war dividend. The president's conclusions are to the effect that new legislation is imperative, that the formation of the central authority so long advocated ought not to be delayed, and that the hydrological survey so long agreed to as being necessary ought to be made. For years we have urged the importance of these matters. In our pages will be found endless references to the importance of our water supply being treated as a thing of national importance. Engineers and medical health and financial authorities are in agreement with Mr. Blackburn, and the Institution of Water Engineers is to be congratulated upon the clear statement of urgent facts contained in the presidential address. The institution is the proper body to bring the matter prominently forward; they have been advancing steadily even during the years of war, as is shown by the report of Mr. F. W. McCullough, of Belfast, the retiring president. The institution now occupies a position of great importance owing to the extent of its membership and to the fact that its members are responsible for the management of waterworks serving a population of 22,500,000, and of a total capital cost of £122,000,000. But this is only a beginning, as there can be very little doubt that the institution will soon include all water engineers of importance in the country. Such a representative body as this has a solemn duty to perform—namely, to urge forward by every proper means the legislation which is of such vital importance to the well-being of the country.

The Passing of Ingenuity

From The Engineer, April 25, 1919.

It was once said of Sheffield that the city was more notable for its industry than its ingenuity. The phrase is one that bites into the mind. Is it possible that a century hence a new race of engineers will use it once more not only of Sheffield, not only of the United Kingdom, but of all Europe and America as well? We see justification for that reproach—for a reproach it is—growing daily greater with every step that leads us to the very things that made Sheffield famous in her day and promised in the end to be her undoing. Only now in her staple trade is she beginning to throw off the lethargy of industry, only now to revive, to re-welcome, imagination and ingenuity. Nothing, in the long run, fails like success. Sheffield brought the manufacture of files and cutlery to the highest position that could be reached by manual methods. She standardized and she specialized and she did all the things that mechanical engineers are now being urged to do in other industries, and the result was magnificent—for a time. Then, when industry had effected its complete mastery of ingenuity, the danger of success began to show itself. Sheffield could not escape from the toils of tradition, she could not throw off the bonds of her standard methods, she could not divert workmen from one way of doing things to another way. We say she could not. That is not quite fair, for she is, in fact, effecting a change, but with infinite difficulty, with pain and tribulation. Ingenuity is coming back to Sheffield; she is winning it back. Will it be recovered by others when their time of trial comes?

It is impossible to change the trend of twentieth century mechanical engineering; it would be bad business to attempt to do so. We are committed irrevocably to mass production, to specialization, to rigs and jigs and standards, to gigantic industrial "combines," to the supersession of individual merit and the apotheosis of mass merit; skill is being transferred from the man to the machine; knowledge is being replaced by the schedule; organization by rule is taking the place of organization by mother-wit; Westminster Conference regulations and Whitley Council rulings are displacing the power of personality, and Welfare systems are regulating bowels of compassion with a card index. We say this flood cannot be stemmed, but let us at least know whither it is bearing us. Let us at least recognize that borne on it mechanical engineering will return whence it was lifted by the old masters, by Newcomen, Smeaton, Watt, Stephenson, Trevithick, Whitworth, Armstrong, Maudslay, Penn, and many another whose ingenuity raised it from a craft to an art. Can there be any but one outcome to the methods which are now commended by the most advanced thinkers, by the Cecil Waltons who propose that from youth to age the mechanic should do but one thing, be it no more than the screwing of three-eighth bolts or the gaging of taper pins; or the less advanced thinkers who are content with the proposition that whole factories should be given up to one product, turning out year after year nothing but 3-in. piston rings, aeroplane connecting-rods, cylinder covers or what not, all to be assembled in due course on an endless moving platform in a factory which does nothing but erection? Many curious prospects are opened by the vision of these later-day works, but none more striking than the obvious fact that technical education of many will be uncalled for. For of what service will it be? What will it benefit a man—we cannot call him an engineer—to know the stresses in a crank shaft when he can procure nothing but standardized patterns, or to be knowledgeable in the matter of armatures when he buys them off the trays like penny buns? Why waste his time on thermodynamics when modifications of engine design are made impossible by the fact that a million or two sterling has been invested in jigs and rigs, and to change them would be industrially uneconomical? The war showed us that to such perfection had we brought machines that even wholly unskilled labor could do highly skilled work; it showed us also that untrained intelligence could fill the duties, within specialized limits, of trained intelligence. But whilst it carried us forward in four years a step that might have taken forty, it has left us with such a deal of momentum that the wheel it started whirling continues to carry us forward on its rim with barely abated velocity. In another 50 years these things we now foresee dimly will be the commonplace of industry. Brought up in standard creches on standard feeding bottles with standard milk, we shall pass through a course of standard education, be dressed in standard clothes, carried in standard conveyances, live in standard dwellings, dine off standard china, behave like standard citizens all our days and in due course be carried in standard coffins in a standard hearse to a standard crematorium.

The prospect of mechanical engineering made perfect in industry and robbed of the disturbing element of ingenuity casts a gloom upon the real mechanical engineer, but it has some redeeming features. The acceleration of output will be so considerable that even the 6-hour day will be found unnecessarily long and men will thus have leisure to ponder upon the happier days of the past when their distant forbears might exercise their creative talents—"It is undeniable," wrote Matthew Arnold, "that the exercise of a creative power, that a free creative activity, is the highest function of man; it is proved to be so by man finding in it his true happiness"—to idle with their collections of curios of a time when there was still some variety in the world; to pore upon old books with their descriptions of varied mechanisms, or to discuss the nuances of the word "ingenuity" marked with an asterisk in dictionaries of the time to show that it was obsolete. Just as in the present day the twisted legs of a Jacobean table carved by hand are more esteemed than those made by the thousand, like rifle stocks, on a copying lathe, so in those days men will value the things that are not to standard, things that show the personality of some ingenious mechanical engineer of an earlier day, more than the standard things to which progress has brought them. Thank Heaven, much water must flow under the bridge before that time comes, and for us mechanical engineers of the present there is plenty of work in the designing of ingenious machines and methods for the murder of ingenuity in our descendants. Much as we may regret its effects, we are forced to admit that the redemption of trade can be secured only by mass production.

Salary of District Council Surveyor, $750 Per Year

From The Surveyor, May 9, 1919.

The proceedings at a recent meeting of the Isle of Axholme (Yorks) Rural District Council, when the salaries of various officials, including that of the surveyor, were under consideration, reveal a state of affairs to which the attention of the Local Government Board should be directed without delay. It appears that the surveyor, who is also sanitary inspector, inspector of canal boats, and housing inspector, receives the magnificent remuneration of £155 ($750) a year, or rather less than £3 a week in respect of all these offices. This being for whole-time service, it will be seen that a miner, for example, is a Croesus by comparison. But this is not all. Out of this salary the surveyor provides his own motor cycle, traveling expenses and office accommodation, and he is, presumably, expected to live on the balance, subject, it is true, to a war bonus of £30. In these circumstances the proposal before the council was that the salary be increased by £25 per annum, and it was actually suggested by one member that the matter should be deferred until the cessation of the surveyor's appointment as local fuel overseer. Ultimately an increase of £15 was agreed to. Such cases as these lead to two conclusions. First, the pernicious system of paying salaries that are inclusive of traveling and office expenses should be abolished; and secondly, that means should be devised for controlling the fixing of salaries by local authorities so as to avoid the possibility of a repetition of such cases as that to which we have referred, which occur all too frequently under present conditions.

London Subways Pays 2 Per Cent Dividends.—In an address May 27, before the London Society, W. M. Acworth said that the dividend on the Tube railways of London, payable after 12 years of waiting, to the ordinary shareholders had not risen above 2 per cent. The capital cost per mile was fifteen years ago, on an average, £600,000. Today the cost would be at least £1,000,000 per mile, and capital could not be obtained for less than 6 per cent. To earn the £[illegible] a year for interest each mile must earn £150,000 per [illegible], which, at the average fare of ¾d (1½ ct.) per mile [illegible] paid, would mean that over each mile of railway [illegible] passengers per week must travel.

Strengthening Old Iron Bridges by Reinforced Concrete Arch Ribs

By MAJOR A. T. DAVIS.

From The Surveyor, July 4, 1919.

The simple and comparatively inexpensive method of strengthening two historic county bridges in Shropshire by the application of ferro-concrete is one which will probably interest municipal and county engineers and highway authorities generally. The bridges in question were constructed with cast-iron arches on masonry abutments about a century ago by Thomas Telford.

In 1821 an old masonry bridge over the river Onny, in the parish of Stokesay, was destroyed by floods, and Thomas Telford, then the county surveyor of Shropshire, built a new cast-iron bridge on an adjacent site during the course of the succeeding year. Having been in constant service for nearly a century, this structure has recently been strengthened by encasing two of the cast-iron arched ribs in ferro-concrete, thus rendering the bridge much stronger than ever, and quite fit to carry the heavy traffic of the present day. The strengthening works were carried out in accordance with the plans and under the superintendence of the writer, on the Mouchel-Hennebique system of Messrs. L. G. Mouchel & Partners, Limited, of Westminster.

In 1917 the bridge was damaged by a traction engine which ran through the railings and also caused damage to the cast-iron curbs and to the masonry of one abutment.

When the scaffolding was erected for carrying out repairs a careful examination of the entire structure was made, with the result that two of the four cast-iron ribs were found to be fractured in several places at the haunches, as indicated in Fig. 2.

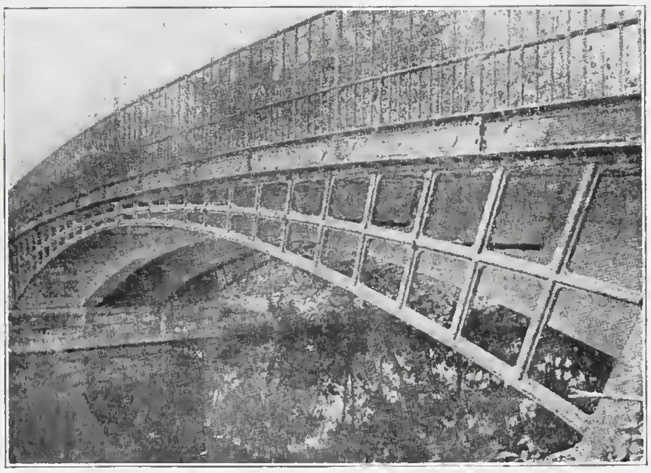


Fig. 1—Stokesay Bridge After Strengthening With Ferro-Concrete Arch Ribs.

Various methods of repair were considered. The idea of strengthening the structure by flitching of fish-plating was regarded as out of the question, partly in consequence of the difficulty of boring rivet or bolt holes in the cast-iron members without causing undue weakness, and partly because of the difference between the elasticity of cast iron and mild steel or wrought iron, but more especially because such treatment would not have increased the weight-carrying capacity of the bridge beyond that of its strength before fracture, ent day. The writer conceived the idea of strengthening which was certainly unequal to the requirements of the pres- the two center ribs by encasing them in ferro-concrete, and prepared a scheme based on this idea, which he recommended to the Roads and Bridges Committee as one calculated to render the bridge fit to carry the heavy traffic of the present day. As no evidence of damage was to be found in the two outer ribs, it was proposed to leave these untouched, thereby avoiding any noticeable alteration in the appearance of Telford's work.

Briefly described, the work of strengthening was performed by constructing two ferro-concrete arched ribs, reinforced as shown in the longitudinal and cross sections in Fig. 3, and enclosing the original cast-iron ribs. The ferro-concrete ribs extend from the top to the bottom of the cast-iron members, and are 18 in. wide. At the middle of the span their width is increased to 3 ft. 6 in. at the top, where they are braced transversely by a horizontal member 12 in. wide and 14 in. deep, the whole being in monolithic connection.

No disturbance of the road surface or hand-railing was involved, as the masonry abutments and the cast-iron floor plates of the bridge were in good condition. The work was executed by the aid of staging and forms suspended from the outer ribs, the timbering being of sufficient strength and rigidity to carry the weight of the concrete, and as the stream is liable to flood rapidly, it was thoroughly secured to the structure for resistance to the pressure of flood water.

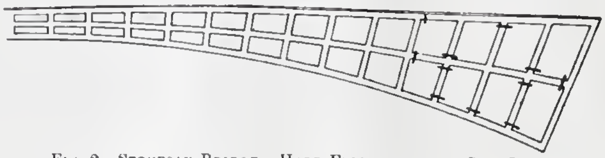


Fig. 2.—Stokesay Bridge. Half Elevation of a Cast-Iron Rib, showing Positions of Fractures.

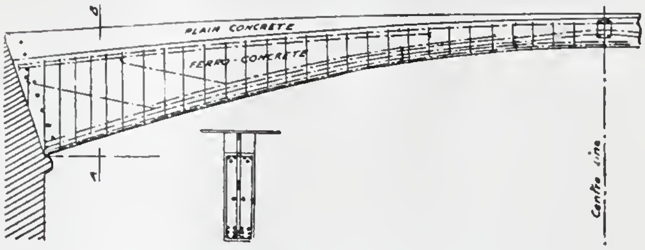


Fig. 3—Section Showing Reinforcement in Ferro-Concrete Work.

The ferro-concrete construction was started from both abutments simultaneously and worked gradually towards the crown, and the plain concrete filling on the upper part of the ribs was added after the ferro-concrete had been completed.

When the reinforcing bars, links and stirrups had been assembled and fixed in place, the work of concreting was commenced, and during this operation and for a period of six weeks afterwards all vehicular traffic was diverted from the bridge, foot traffic being permitted as usual. The original intention was to strengthen one rib at a time, thereby enabling the bridge to be used for ordinary light traffic, first on one side and then on the other. It was, however, finally thought better to undertake both ribs at the same time, and thus avoid all vibration, a course which resulted in very little inconvenience to the public owing to the existence of a by-road at a short distance away, over which all vehicular traffic was temporarily diverted

The strengthening works have been found perfectly satisfactory in every way. The bridge is now capable of bearing without undue strain a rolling load of 30 tons on a 10-ft. wheel base, and was opened to traffic on Sept. 2nd last. The characteristic features of Telford's original design have been preserved so far as the exterior of the bridge is concerned, the ferro-concrete ribs being unobtrusive and hidden from view to a considerable etxent by the outer cast-iron ribs.

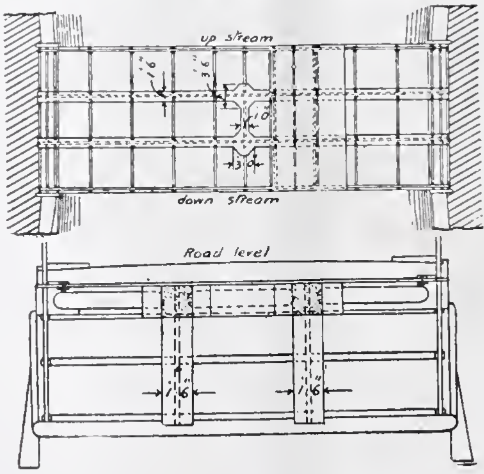


Fig. 4—Plan and Cross-Section of Stokesay Bridge, Including Ferro-Concrete Ribs.

The highly successful results given by the method of strengthening Stokesay bridge in the manner described encouraged the writer to make a similar application of ferro-concrete for the purpose of strengthening another cast-iron bridge built by Telford when occupying the position of county surveyor of Shropshire. This structure, known as Cound bridge, is four years older than the similar bridge at Stokesay, having been constructed in the year 1818. It is therefore more than a century old at the present date, and having been thoroughly strengthened by enclosing two of the cast-iron ribs, the structure has obtained a new lease of life and may be expected to continue its useful career well into another century.

The bridge is practically of the same design and dimensions as that at Stokesay. It is a little narrower than the latter, but the span is exactly the same. Another interesting point is that the two center, or weight-carrying, ribs cracked in a precisely similar manner to those in Stokesay bridge, but to a somewhat greater extent.

The scheme prepared by the writer for strengthening the bridge by means of ferro-concrete was on exactly the same lines as those in connection with the bridge at Stokesay, and the work was carried out on the Mouchel-Hennebique system in accordance with the working drawings prepared by Messrs. L. G. Mouchel & Partners, Limited, of Westminster. Messrs. Hobrough & Company, of Gloucester, were the contractors.

Concreting was finished on Christmas Eve, and the bridge is now carrying the whole of the traffic. In contradistinction to the procedure adopted at Stokesay bridge, all vehicular traffic up to 5 tons in weight was allowed to use Cound bridge during construction, movable barriers being used for the control of traffic and to keep it at a walking pace. It may be mentioned that, although the staging was suspended, as in the case of Stokesay bridge, it was stiffened by piles driven into the river bed, and that the vibration produced by the restricted traffic was negligible.

Hysteresis in Reinforced Concrete Structures.—In a paper on reinforced concrete ships, presented March 27 before the Concrete Institute, Mr. J. S. E. De Vesian stated that he had found that the use of ordinary mild steel bars with an ultimate tensile strength, say, at rupture of about 63,000 lb. and the yield point corresponding to about 32,000 lb. per square inch, accounts for a large part of the slight sagging which is noticed in reinforced concrete structures after they have been loaded or stressed for the first time. This sagging does not increase by subsequent stressing, and in order to obviate the appearance of such sagging, engineers or architects are in the habit of specifying that the beams should be moulded with a slight camber. Mr. De Vesian considers that this initial sagging is due mostly to the phenomenon of initial permanent set, or "hysteresis," to borrow the term used by electricians to denote a similar phenomenon observed in their sphere of knowledge; and it is also exhibited by ordinary steel structures when stressed for the first time. In the case of reinforced concrete, however, this initial set causes initial stresses in the surrounding concrete, and although less important in the case of ordinary building construction if proper factors of safety are allowed, in structures like ships where alternating stresses occur through hogging and sagging, the initial permanent set in the steel produces a somewhat unelastic state in the structure which is detrimental and materially increases the tendency of cracking of the concrete, which for obvious reasons must be avoided in ships. Mr. De Vesian's firm therefore decided to adopt a form of bar of which they had had previous satisfactory experience. These bars are made from ordinary mild steel and are more or less triangular in section with rounded corners. They are subjected to a special process of twisting, the effect of which is to produce in the bar that initial permanent set which would take place in a plain bar when first loaded. This twisting has also the effect of producing an efficient continuous bond and increases the elastic limit with a proportionately less elongation under calculated stresses.

Wood for Reinforcing Material for Concrete.—According to Beton u. Eisen, wood used as a reinforcing material for concrete should be impregnated with magnesium chloride, and should be so placed that any change in the cross-sectional area does not affect the durability of the structure. If the latter precaution is overlooked the concrete may crack. Small strips of wood are better than larger ones, and rushes appear to be excellent for the purpose, especially for thin walled structures such as ships.

The Maximum Temperature in Large Tunnels and Deep Wells With a Trial Empirical Formula

By F. BUTAVAND,

From Le Génie Civil, May 10, 1919.

At the surface of the ground, the temperature varies, according to the season, from the mean annual temperature (t) of the locality. Below the surface the size of the variations decreases; at a depth of a few decimeters, the diurnal variations cannot be detected and at a depth of a few meters, the temperature remains constant with a value a little greater than t, or t + a. At still greater depth, the temperature increases with the depth H. It increases also with the length L, in the case of a tunnel, for this depends upon the curvature of the mountain or, in other words, the form and extent of the cooling surface.

The relation may be shown by an expression with the form:

$$b H^{\alpha} L^{\beta}$$

and the complete formula will therefore be:

$$T = t + a + b H^{\alpha} L^{\beta}$$

a and b are not strictly constants but depend upon the conditions which cannot be exactly expressed, such as: the form of the ground surface, the variable conductivity of different rocks, chemical activity, sources of heat and cold, etc. Consequently it is impossible to verify the formula perfectly.

Ordinarily the following values can be used:

$$a = 4,\ b = \frac{1}{3.5\ n},\ \alpha = 1,\ \beta = \tfrac{1}{2}$$

and

$$T = t + 4 + \frac{1}{3.5\ n} H L^{1/2}$$

where H is the maximum depth of earth overhead, expressed in hectometers, L is the length of the tunnel expressed in kilometers; t is mean annual temperature of the region at the same elevation as the tunnel, expressed in degrees Centigrade; and T is the temperature in the tunnel in degrees Centigrade.

As for n, it is a coefficient which, in the theoretical case of a tunnel in a cylindrical mountain, would equal 1. When the tunnel is near high summits this coefficient becomes less than 1. In the case of a spherical surface n = 2.

For most large tunnels a value of 1 can be given to n. For the Simplon tunnel, where the maximum thickness over the tunnel is 2,850 meters and where, in the immediate vicinity there are mountains more than 4,000 meters high, it would be well to use a smaller value for n, for example, 0.8.

The use of this formula for five large tunnels gives the following results:

	Mont-Cenis.	Saint-Gothard.	Arlberg.	Simplon	Loetchberg.
t..............	10	10	10	10	10
H..............	16.1	17	4.7	21.5	17
L..............	12.2	14.9	10.3	19.8	14.5
n..............	1	1	1	0.8	1
T calculated..	30°	32.7°	18.3°	48°	32.5°
T observed...	29.6°	30.8°	21°	47°	34°

It should be noted that in the Simplon tunnel, near sources of heat, temperatures from 49° to 53° have been found.

Consider now the application of the formula to the Czuchow wells in the plains of Silesia, south of Glewitz. These wells have a depth of 2,240 meters. Here it is necessary to consider the terrestrial zone limited by a horizontal plane passing through the bottom of the well. The length of the chord will be 333 kilometers.

This gives:

$$t = 10,\ H = 22.4,\ L = 333,\ n = 2$$

by substituting and solving, the formula gives T = 72.5° C. observed T is 83° C.

The error is due principally to proximity of the Carpathean Mountains which lowers the value of n from 2 to 1.70.

In the case of wells driven in a plane, the proposed formula

$$T = t + 4 + \frac{1}{3.5\ n} H L^{1/2}$$

may be given a more simple form. Here $n = 2$ and L is substantially equal to

$$2\sqrt{\frac{DH}{10}}$$

D being the diameter of the earth. Substituting for D, this becomes

$$400\sqrt{\frac{H}{10\pi}}$$

and the formula is reduced to

$$T = t + 4 + 1.2\ H^{5/4}$$

Since this formula was established, the United States Geological Survey has published the temperatures obtained in wells located about 8 kilometers north of Clarksburg, W. Va. These wells, which have approximately the same depth as the ones at Czechow, have a temperature of 66.7° C at a depth of 2,133 meters. The formula with $t = 10$ gives $T = 69°$ C.

The artesian wells at Grenelle and Passy at Paris have a depth of 550 meters and 620 meters, respectively. The temperatures given by the formula for these depths are 25° C. for the first and about 27° for the second. The temperature of the artesian water is 28°.

To summarize, it may be said that the proposed formula has been verified with a mean error of 6 to 7 per cent for tunnels and wells.

A temperature of 100° C., where boiling water and steam will be found, will be reached at the following depths according to the mean annual temperature of the region:

	m
t = 0°	H = 3300 ±
10	= 3000 ±
20	= 2750 ±
30	= 2500 ±

The formula also shows that the geothermic degree, SH, or the increase in depth corresponding to a difference of 1° C. is not constant. It is represented by:

$$SH = \frac{1}{1.5\ H^{1/4}}$$

which gives

$SH = 55$ meters for $H = 200$ meters
$= 38$ meters for $H = 900$ meters
$= 30$ meters for $H = 2{,}500$ meters.

Protection of Zinc Water Pipes from Corrosion.—Zinc water pipes in contact with mortar containing gypsum become in a relatively short time corroded and eaten through in places, states the Building News. Where the surface is wetted and quickly dried a protective coating of oxide is formed; but where the contact with running rainwater is prolonged, as in the case of roofing plates and gutters, the possibilities of energetic action must be reckoned with. The most active agent of destruction is sulphate of lime. Zinc is energetically attacked by mortar containing gypsum sand, but only feebly by mortar containing limestone sand alone or with an addition of gypsum. Lead, on the other hand, is energetically attacked by limestone alone and with an addition of gypsum, but only feebly by gypsum sand mortar. Both metals are strongly attacked by pure cement, but the destructive action is lessened in progressive measure by the addition of sand. Hence zinc should be put in contact only with limestone—carbonate—mortar, and lead only with gypsum—sulphate.

Concrete Pipes for Wharf Substructure.—Pipes made of concrete are being used instead of wooden piles in the construction of the wharf inside the new breakwater at Burnie, Tasmania, according to The Engineer of June 20, 1919. The concrete cylinders are 10 ft. long by 4 ft. 6½ in. in diameter, the concrete being 12 in. in thickness. To produce them a steel cylinder is placed on four wheels, and driven by an electric motor, revolving at the rate of from 250 to 300 revolutions per minute, the concrete is thrown in, and the centrifugal force thus produced gets rid of the water. It takes about a quarter of an hour from the time the mould is set in motion until the concrete cylinder is ready for removal. To obtain the necessary height in constructing the wharf, the concrete cylinders will be placed on top of each other, cemented together, and secured by an 8 in. steel band on the outside of the joint. The hollow space in the cylinders will be filled with sand.

Chlorination Results in Treatment of Water Supply of London

From The Engineer, July 4, 1919.

The 13th annual report made to the Metropolitan Water Board by Sir Alexander C. Houston on the results of the chemical and bacteriological examination of the London waters during the 12 months ended March 31st last has just been published.

Treatment of Raw Thames Water.—The chlorination of raw Thames water was continued during the period under review. Between April 1st, 1918, and March 31st, 1919, 20,841 million gallons were treated during 286 days for the West Middlesex supply and during 261 days for the rest of the Staines supply out of a total of 365 days. The intermissions were caused by floods when the water was too turbid for filtration purposes, and stored water had to be used instead. The proportions were 74.3 per cent. raw and 25.7 per cent. stored water during the year. The estimated saving of money due to a less amount of coal being required for pumping was £13,547. The cost of chloride of lime was about £3044, so that the net saving amounted approximately to £10,503. These calculations, it is explained, were based on figures given by the late Sir J. W. Restler in 1916, since which time the price of coal has risen, whereas the price of chloride of lime has fallen. The dose was varied according to circumstances, but, on the average, it was 1 in 2¼ millions, or 0.44 in one million, in terms of available chlorine. With bleaching powder—chloride of lime—of 33 per cent. strength that proportion equals 13.33 lb. per million gallons. As regards bacteriological results, all that is now aimed at is to produce at least as good a result, judged by the B. coli test, by chlorination of raw river water, as if the river water had been stored in Staines reservoirs instead of being chlorinated. The bacteriological results achieved by the treatment were actually better in winter than in summer, and the facts were established that chlorination succeeds considerably better than storage on the average and is practically three times superior during the winter months, when both the river water and the stored water give the least satisfactory results.

The foregoing remarks refer to unfiltered water only. As regards filtered water, B. coli tests showed that the 1918-19 results—obtained by chlorination—were, as compared with the 1906-16 averages—i. e., in the pre-chlorination period—fractionally worse as concerned Kempton Park water, which in prechlorination times was remarkably good; distinctly better with East London—Sunbury—and Grand Junction water; and exactly the same with West Middlesex water.

Commenting on the results, Sir Alexander says: "The war is now over, and the time has perhaps come when, as the result of nearly three years' experience, an opinion should be given on this subject unequivocally and on a postwar basis. The writer considers that the chlorination treatment has been such a pronounced success that as long as there is a clear economic gain by its use. It is most desirable that it should be continued indefinitely as a post-war measure."

It is noteworthy that despite the magnitude of the treatment—from 70 to 80 million gallons of Thames water were treated daily—no complaints had been received from consumers since it was first started in June, 1916.

Super-Chlorination and De-Chlorination.—Turning to the question of the treatment of New River water, Sir Alexander remarks that the period under consideration would have afforded an excellent opportunity for testing the value of super-chlorination and de-chlorination, since it turned out to be a year of phenomenal floods. Most unfortunately, however, it coincided with a time when it seemed almost impossible to get anything done, owing to the remarkable shortage of essential materials and the extreme difficulty of obtaining reliable labor. It was not until the beginning of March this year that after many vexations although unavoidable delays the plants at Highfield and Wood Green were in running order.

At the former place there are two plants for super-chlorination. The bleaching powder—chloride of lime—plant is designed broadly on the plan of those already in use in the Thames Valley which were described in the 12th report, except that, in addition, there was a sludge settling tank from which the clear liquid can be pumped back into the mixing tanks. In the other plant liquid chlorine is employed. The chlorine gas is accurately measured, dissolved in water and discharged as a solution into the New River channel in such a way as to ensure thorough mixing.

From March 3rd to 14th bleach solution was used, the dose being 1 in 2 millions—in terms of available chlorine—from the 3rd to the 10th, and 1 in 1.3 millions from the 11th to the 14th. Thereafter, till March 27th, when the treatment was stopped, chlorine gas solution was employed in the following strengths:

March 15 to 18	1 in 1 million
March 19 to 21	1 in 2 millions
March 22 to 27	1 in 1 million

At Wood Green there is a single dechlorinating plant, sulphurous acid being employed for the purpose. The sulphurous acid is measured, dissolved in water and delivered as a solution into the New River channel. The dechlorinating apparatus was at work during the same period as the superchlorination was in progress. The dose was nominally based on the excess of chlorine still present in the New River water when it reached Wood Green after flowing a distance of between 2½ and 3 miles, which it took about seven hours to do. As a matter of fact, it was found best, with a view to avoiding "taste" troubles, to add rather more of the sulphurous acid solution than was actually required for neutralising the free chlorine. The treatment lasted from March 3rd to March 27th inclusive, and during that time there were two floods and the weather was exceedingly cold.

The water supplied to consumers had no appreciable taste until March 20th. From that date onwards, however, and until some days after the treatment had been stopped, "taste" troubles arose and a large number of complaints were received. The water from the Stoke Newington and Clerkenwell Works had so little taste throughout the period named that it could only be detected by persons with specially sensitive palates. The Hornsey water, however, had, beyond question, an unpleasant taste, but it was noteworthy that a chlorinous or "iodoform" flavor was seldom observed—as our readers will remember had been the case on former occasions—the taste being nearly always of "a vegetable, muddy, or 'froggy' nature." It is put forward as bearing on this question that the Hornsey filters were fed with treated water which had undergone hardly any settlement in the small Hornsey reservoir, whereas the Stoke Newington and Clerkenwell filters were fed with the same treated water, which had travelled subsequently a considerable distance down the New River and had received as well much more satisfactory settlement in Stoke Newington reservoirs. Furthermore, a portion of the Stoke Newington and Clerkenwell water was diluted with filtered Thames water.

Apart from the matter of "taste," the bacteriological results were, however, excellent. At Highfield, just above the point where the water was treated, out of 250 cultures from 25 daily samples of raw New River water, 192—or 76.8 per cent.—contained B. coli in 1 c.c. At Wood Green after dechlorination, out of 250 cultures from 25 daily samples, 247—or 98.8 per cent.—contained no B. coli in ten times as much water—10 c.c. The filtered water results—at Hornsey, Stoke Newington, and Clerkenwell alike—were equally remarkable, as is seen in the following table:

Week ending—	Percentage number of samples containing no B. coli in 100 c.c.
February 22	28.0
March 1	16 0
March 8	52.0
March 15	96.0
March 22	92 0
March 29	88.0
April 5	96.0

In considering these figures it should be borne in mind that the higher the figure the better the result, and that the treatment began on the 3rd and ended on the 27th. With regard to the high figure for the week ending April 5th—after the treatment had been stopped—Sir Alexander remarks that the water probably benefited greatly by the highly improved condition of the water in the Hornsey and Stoke Newington reservoirs as the result of the previous chlorination, although no doubt the improving condition of the raw New River water, owing to the decline of the flood, was a factor in the situation.

As concerns the future, Sir Alexander considers that the outlook of chlorination treatment is, to say the least of it, promising.

Resistance of Various Waters to Filtration.—The series of investigations into the resistance to filtration of various waters, which was discussed in the 12th report, was continued during the period under consideration with interesting results. In alluding to the matter generally, Sir Alexander remarks that four years' experience has shown that about April and May filtration results are not very satisfactory. This condition of affairs is not, he explains, due to floods, but to a seasonable development of diatoms, such, for example, as Synedra, and the effects, apparently, of bright sunshine and increased temperature. At that period of the year, he says, "fermentative changes seem to occur in the bed of the river leading to masses of suspended matter, buoyed up with bubbles of gas, rising up and rendering the water turbid. Chiefly composed of amorphous matter, the accompanying diatoms give this material a viscid character, which exercises a considerable clogging action on filtration." It is remarked upon as a curious circumstance that the growths noted in river water are not usually the same as those that develop most abundantly in storage reservoirs.

After May, or at all events June, excellent filtration results may be expected until the late autumn or winter floods, during which the suspended matter is largely amorphous, while living growths are, relatively, absent, and there can be no doubt that the blocking effect on filters is almost entirely due to mud. As was the case in the 12th report, numerous reproductions from photographs of samples of water are given in the present report. The photographs are taken at regular intervals as part of the general routine work, and they have been found to be of great value. By means of them Sir Alexander has been able to put the waterworks engineers on their guard for possible blocking of filter beds. Evidently he can occasionally give warning of impending trouble some considerable time ahead. In one instance which he quotes he informed the engineers specially interested that it was possible that there might be blocking in certain filters. It was actually eighteen days later that difficulty in filtration was experienced.

Rapid Filtration and Chlorination.—The question of rapid filtration and chlorination is dealt with. It is pointed out that the great pecuniary success of the Thames chlorination experiments has been due to the fact that it is much cheaper to chlorinate river water and allow it to gravitate directly or indirectly on to the filter beds than to pump it instead into reservoirs and, after storage, to use it for filtration purposes. Unfortunately, only from 70 to 80 million gallons per day out of the total supply from the Thames can be gravitated in this manner.

The cost of slow sand filtration is usually stated to be 28s. per million gallons filtered, of which about 20s. represents interests on capital expenditure. The advocates of rapid mechanical filters contend that their methods of purification work out much more cheaply, "and so they do," comments Sir Alexander, "if the speed of filtration is increased to an extent enormously in excess of the older methods." "Obviously," he adds, "this cannot be done without serious loss of quality, and to overcome this difficulty the advocates of the newer methods use alum as a coagulant, and, especially with selected waters—e. g., moorland—the results obtained are in most respects remarkably good. Nevertheless, the cautious observer may find that the cost of the alum, together with the interest on capital expenditure in connection with the alum mixing and settling tanks, and the necessity of keeping the rate of filtration within reasonable limits to ensure the same degree of purification in the case of initially impure waters, may render the economic advantages of rapid filtration less apparent than would at first appear to be the truth

There is no doubt, however, Sir Alexander thinks, that if the use of alum could be obviated, the speed of filtration maintained at an exceedingly high rate, and some means found to purify finally the water at low cost, rapid mechanical filters would be far cheaper than the slow and filtration system. Chlorination is, he says, very cheap, and its use would render the employment of alum and slow filtration rates unnecessary, subject to certain considerations

A large number of experiments in connection with this subject has already been carried out. Some of them were effected under laboratory and some under "field conditions." For example, a very small mechanical filtration plant was tried at Hampton, the water dealt with being raw river water after four hours' preliminary settlement—continuous flow The rate of filtration was varied from 50 to 100 gal. per square foot per hour, and a fair degree of purification was obtained. The color was usually reduced about 50 per cent. at the lower and 30 per cent. at the higher rate. In addition a large number of bacteriological experiments was made with Walton reservoir water—before filtration in order to determine the dose of chlorine required for sterilization purposes in five hours at low temperature—about 3.5° C. The experiments were carried out at a time when, owing to the winter floods, Walton reservoir water was at its worst. The results, states Sir Alexander, appear to be quite conclusive and to point to an average dose of 1 in 2.5 millions, or 12 lb. per million gallons, being effective, even when dealing with unfiltered water. Taking chloride of lime of 33 per cent. strength in available chlorine at the current price of £22 15s. per ton, the cost would work out at 2s. 5¼d. per million gallons. As regards the character of the machinery being employed in the investigations, we give the following passage in its entirety: "It was hoped to have an installation at Hampton working six months ago on a sufficiently large scale to allow of practical conclusions being drawn. Unfortunately, unavoidable delays were experienced, and it is only now—April—in working order, although not fully 'matured,' a circumstance of importance in relation to purification. It consists of a mechanical filter which will deal with Walton stored water, filtering, without the use of alum as a coagulant, at the rate of, say, from 50 to 100—or more—gallons per square foot per hour. The physical, chemical and bacteriological characters of the filtrate will be carefully observed. The filtrate will pass through a tank holding five hours' flow and it will be sterilized with chlorine. The cost of ordinary slow sand filtration per million gallons is, as previously stated, usually put at 20s.—interest on capital expenditure—and 8s. for working expenses. The question is how far is it possible to reduce this cost—28s.—materially by the use of rapid filters followed by sterilization in a five hours' flow tank without loss of any of the really important attributes of quality and with equal or greater security from the epidemiological point of view. It goes without saying that any new or altered procedure which trespasses on the margin of safety will not be seriously entertained by the writer. A great deal depends on whether a high speed of filtration can be maintained without the use of alum and yet satisfactory results obtained. The use of a coagulant means a considerable increase of cost, partly due to the interest on capital expenditure on mixing and settling tanks, and also to the very considerable cost of the chemical even if employed in small doses."

Sir Alexander's laboratory experiments seem to show that at rates of filtration sufficiently rapid to compete economically with slow sand filters some of the suspended matters in stored water may pass through. It is curious, however, that even if the rate be enormously increased the results do not show any marked deterioration in that respect.

It would be possible, Sir Alexander remarks, to be more explicit, but he is satisfied if he has made out a prima facie case for scientific investigation in relation to prospective new works. We could have wished that he had given a little more information regarding the results he has achieved up to the present time, and shall look forward with interest to his next pronouncement on the subject.

In conclusion, Sir Alexander remarks that at certain works of the Board it would appear to be practicable to chlorinate after filtration. This circumstance, he remarks, opens up the question of whether in times of maximum consumption the rate of filtration should not be greatly increased at those works—with subsequent chlorination—in order to keep the speed of filtration at some of the other intercommunicating works within reasonable bounds.

British Institution of Municipal Engineers Secures Increase of Surveyors' Salaries.—As a result of' representations made to the Galway County Council by the Institution of Municipal Engineers, the salaries of seven assistant surveyors to the authority have each been increased by £50 per annum, bringing the total up to £200, while further consideration is promised later. Protests against inadequate salaries are being made by the institution to other councils in Ireland. It appears that up to the present the officials concerned have been in receipt of the same salary—working out at about £2 17s. 6d. ($14) per week—as was paid them 5 years ago, and it was proposed to the county council that each of them should be paid a war bonus (on Civil Service scale) for the period from May 1, 1918, to April 30 last, and given a 100 per cent increase on his 1914 salary, or a minimum of £250 per annum, whichever was the greater.—The Surveyor. June 20, 1919.

The Ventilation Plant of the Simplon Tunnel

From Engineering, April 11, 1919.

The original ventilation plant of the Simplon Tunnel, single in the first instance, was projected by the contractors, Brandt, Brandau & Co., for the construction period rather than for the permanent tunnel service. Two ventilating fans, to be coupled in parallel or in series, were placed at each entrance, Brig in the north, Iselle in the south, each capable of giving 25 cu. m. of air per second at a pressure of 250 mm. of water. By the time the second tunnel was being constructed the transference of the power station to Massaboden had deprived the turbines driving the fans of their water, and the new ventilation plant was designed both for the second period of the building operation and for the permanent ventilation of the two tunnels. Although the old plant had admitted of working with compression or with suction from either tunnel end, the practice had been to force air into the tunnel at Brig and to withdraw it at Iselle. That practice necessitated the provision of a screen at either end.

The new project, which was actually taken in hand in October, 1913, provided for the erection of one ventilation plant only, and this plant was laid down at Brig. A selection had been made in favor of Brig because the central power station was there, because the whole organization of the tunnel service was concentrated at that town, and because meteorological observations proved that the barometric pressure is in general higher at the northern entrance than at the southern entrance, so that the maintenance of an air curret from north to south required less power than a current in the opposite direction.

The best solution of the problem would, of course, have been to have the current in each tunnel in the direction of the train motion, i. e., to force air into tunnel No. 1 at Brig while withdrawing it from tunnel No. 11 at Brig. This plan was not adopted because it had been observed that, when the air was taken in at Iselle, all the iron in the tunnel structure rusted badly. The reason is meteorological. The air at the southern entrance is mostly warmer and more moist than at the northern inlet at Brig; air travelling to the north in the tunnel therefore deposits its moisture as it becomes cooled.

In order to reduce the air resistance to the train and the power demand on the ventilation plant it was decided to open the curtain at Brig, when a train starts at Iselle northwards in tunnel II and to shut the ventilation down for the time of the passage. The maximum air supply was fixed at 90 cu. m. per second for each tunnel, that is, at 180 cu. m. per second altogether, which is a large quantity. The velocity of the air current was fixed at 3 m. or 4 m. per second; a higher air velocity would be decidedly unpleasant to the men in the tunnel. Projects submitted were to conform to these main conditions. The chief firms whose tenders were accepted were Sulzer Brothers, of Winterthur, the general contractors; Brown, Boveri and Co., of Baden, for the electrical plant; and J. Bolliger and Co., of Zurich, for the buildings and the ventilation trunks. In giving a general sketch of the new arrangements we follow a series of articles which Mr. F. Rothpletz, of Bern, has published in four recent issues of the Schweizerische Bauzeitung.

As regards the resistance which the air current would have to overcome, Messrs. Sulzer calculated that the resistance in the tunnel would amount to 60 mm. or 70 mm. of water; 4 mm. more were allowed for the resistance in the feeder trunks. A further factor to be considered was the barometric difference between the two tunnel openings. In general the barometer stands higher at Brig than at Iselle, the difference amounting to 115 mm. of water in exceptional cases. Cases where the atmospheric pressure was higher at Iselle than at Brig were also observed; they are rare, however, and this excess never exceeded 70 mm. The fluctuations in the barometric pressure were, in any case, sufficiently great, however, to make speed regulation of the ventilators desirable, and the specifications called therefore for the following normal (and minimum) figures for each of two ventilators: Air feed in cubic metres per second, 180; head in millimetres of water, 130 (70); effective horsepower at the ventilator shaft, 500 (300); revolutions per minute, 325 (240); efficiency, 0.72 (0.65). The average density of the air is 1.15.

Each ventilator is a fan, 3.5 m. external diameter, 1,564 mm. width, with a central suction opening 2,600 mm. in diameter; the six parallel rows of buckets, built up of wrought-iron blades and partitions, take up 1,284 mm. of the width of the wheel; the hub is of cast iron. The two fans have been mounted in the same building, the one above the other; the air conduit from the lower fan is therefore steeper than that of the other, and the two conduits unite at an acute angle at which the main valve is hinged. This valve, 7.85 m. long and 4.5 m. wide, closes either the lower or the upper conduit, being raised or lowered by machinery or by hand with the aid of two wire ropes. When only one fan is working, this valve closes the other channel; when both fans are run in series, the one draws in air through its suction gate and sends it through the second fan; one conduit thus remains again closed. There are further four valves for the accessory air channels. Each fan weighs 12 tons; the electric motor driving it weighs 11 tons, and the regulating devices, transformers, switches, etc., more than double the latter figure. The casing of each fan is brickwork, except the first helical portion which is made of sheet iron; the two conduits are square in section, the side being 4.5 m.

Each fan is directly coupled with an asynchronous three-phase motor which is fed with railway currents of 3,200 volts at 16⅔ periods. The speed regulation is effected on the Brown-Boveri-Scherbius system; the rotor current of the motor is not absorbed by resistance, but serves to feed a three-phase collector motor which is coupled with an induction generator sending its current back into the mains; this regulating apparatus alone weighs 9.5 tons. The whole building is a ferro-concrete structure. The lower fan rests on a massive block of concrete; the upper fan is mounted on ferro-concrete beams, but the base is separated from the other parts of the building.

We mentioned that each northern tunnel entrance can be closed by a screen or curtain. For this purpose a portal frame of iron is built into the brickwork, about 2 m. from each tunnel end; the curtain is suspended in the frame by means of chains and can be raised or lowered by means of electric devices or by hand. The lower edge of the curtain, which is made of impregnated sailcloth, is held by a rope of soft copper wire; the track in the plane of the frame is levelled up to the railhead with concrete, and the copper rope rests fairly airtight on the concrete surface when the curtain is lowered. Should accidentally the curtain be down when a train is approaching, the engine would burst through the curtain and the rope of soft copper wire without endangering the train. The curtain is automatically operated with the aid of track contacts.

The cost of the whole ventilation plant amounted to 486,973 francs ($94,000); earth and brickwork and mechanical appliances cost 139,169 francs, the fans and electrical apparatus 187,343 francs, the building 100,496 francs, and the trunks from the ventilation building to the tunnels 59,965 francs. The main installation work was completed in 1914. At the acceptance tests the specified performances were exceeded, although the consumption of electric energy was below the calculated figure; the full air-pressure head was not quite realized, however. The air temperature in tunnel I was lowered, from 29° and 30° C. with the old ventilation, to 23° and 25° C. with the new ventilation; these temperatures were measured at distances of 7 km. and 8 km. respectively from the north entrance. At the south entrance observations could not be conducted during the war. It has been noticed that the air-pressure heads adapt themselves to fluctuations in the barometric pressures; but tunnel II is not yet quite completed and final results cannot be stated at present.

35 Per Cent of Membership of Institution of Municipal and County Engineers in War Service.—In the annual report of the Council of the Institution of Municipal and County Engineers of Great Britain, submitted on June 26 last, it is stated that 624, or nearly 35 per cent of the total membership were in active service during the war. The total membership in 1919 was 1,803, a net increase of 41 over the previous year.

$50,000,000 Water Supply Project for Manchester.—The House of Commons Select Committee has sanctioned a new water supply scheme for Manchester, England, that will call for an expenditure of about $50,000,000.

The Causes of Erosion of River Banks

By COL. HOC.

From Le Génie Civil, March 15, 1919

Comparison with the Bending of a Compressed Flexible Column.—The remarkable tendency of a river to assume a sinuous course does not seem to have been studied deeply. The ordinary explanations of these meanderings are incomplete and inaccurate.

Often it is attributed to unequal resistance of different parts of the river bed or to the deflection of the current from one bank to the other. However, the phenomena of erosion is observed in the most uniform soil and also on shallow gravel beaches where the transverse current would be feeble.

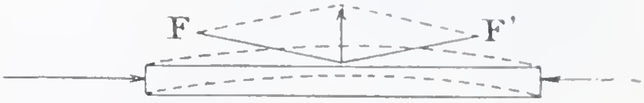


Fig. 1.

It is sometimes said that the centrifugal force of the current attacks all banks which are slightly concave, or that the liquid mass forms eddies whose erosive power is considerable. But these explanations, though they may be correct in many cases, do not show why the tendency of a stream to meander is so variable, at a maximum in certain quiet stretches and entirely lacking where the current is rapid. Close observation of views shows cases where the convex bank is eroded, thus straightening the stream bed and not increasing its curvature as would be the case were centrifugal force the cause.

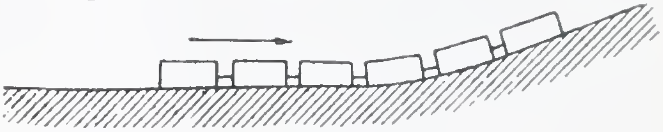


Fig. 2.

Finally, this phenomena is attributed to the deposits in the stream, but this applies to only a few cases.

It seems possible to clear up and co-ordinate these different ideas by using the analogy that the curve of the current of a liquid is like the bending of a loaded flexible column.

The phenomena of flexure is well known. All bodies with one long dimension are in a state of unstable equilibrium when compressive forces are applied parallel to this dimension and all transversal bending tends to increase. When the two compressive forces F and F' (Fig. 1) are applied in a direction not parallel to the axis, a transversal component is developed.

But the theory of flexure is applicable to a mobile system as will be shown later. For the present, let us consider a system less complex than a river such as a wagon train of exactly similar carts descending a slope in a straight line and moved only by gravity.

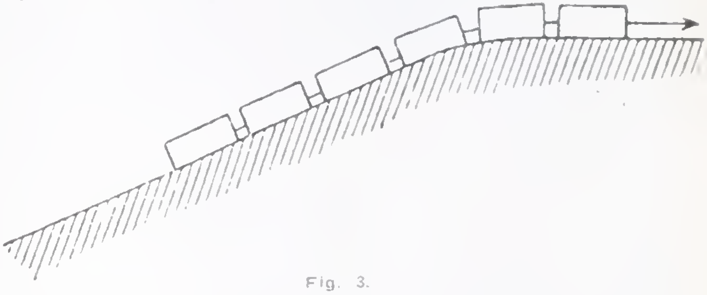


Fig. 3.

If the slope is uniform and just sufficient to overcome the rolling friction, all of the carts will have a uniform speed with neither compression nor tension on draw bars.

But if the speed of the front cart is decreased either because the brakes are applied or because the slope becomes less steep, it is evident that the drawbars of the train will be compressed. It is also evident that this compression will tend to increase any accidental lateral displacement and force the carts to slide to one side of the road. Compression as with a column produces flexure.

On the other hand, if the speed of the front cart is increased by decreasing the rolling friction or because the slope becomes steeper, the drawbars are put in tension and there is no longer any tendency to increase any existing curvature but instead the train straightens out.

Therefore the two phenomena which we shall try to prove to exist in streams are:

(a) A tendency to curve, by eroding one of the banks, when the velocity of the river decreases from upstream to downstream either because the resistance of the stream bed is increased as, for example, the case of a river flowing through a narrow gorge or because the slope decreases. If the banks are already curved, then centrifugal force helps to increase the erosion.

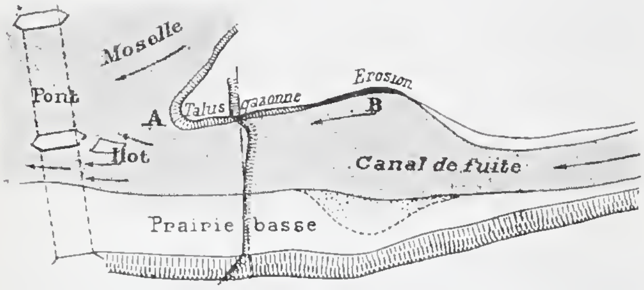


Fig. 4—Plan of Canal Flowing Into the Moselle.

(b) A tendency to straighten the channel by eroding the convex bank, when the velocity increases from upstream to downstream. This tendency opposes centrifugal force.

Examples.—When little drops of rainwater run down a greasy windowpane they do not flow in a vertical line, but turn sharply from side to side. This is a simple form of the first phenomena. The stream, slowed up in front by the resistance, undergoes up stream the transverse flexure of a loaded flexible column.

Considering now several actual examples, a strong tendency for rivers to erode the banks above bridges and dams will be proved. This is shown in Figs. 4, 5, 6 and 7.

Figure 4 shows a canal flowing into the Moselle at Toul when the water level of the river is high. This high water level of the river offers resistance to the discharge of the canal whose outlet is moved from its usual outlet at A (Fig. 11) just above the pier of the bridge. At B, the curving of the current with the corresponding erosion of the bluff can be clearly seen.

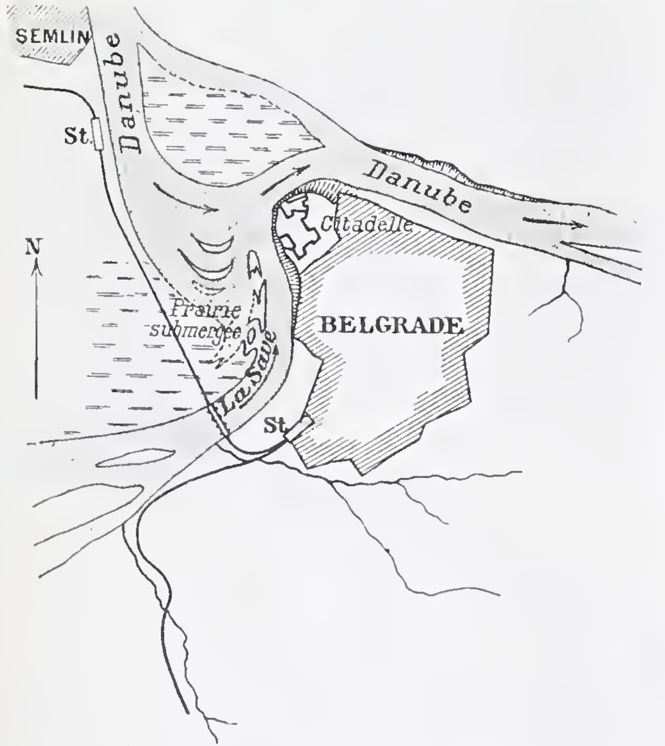


Fig. 5—Map of the Danube Near Belgrade.

Figure 5 shows the junction of the Danube and the Save Rivers at Belgrade (as seen in July, 1914). At the foot of the rocky bluff below the citadel, the mass of water in the Danube runs into the double obstacle of a narrow channel and the discharge of another large river. It can be clearly seen that if this mass bends it is because of this resistance and for no other reason. The crescent shaped deposits which separate the different arms have too little relief and are too mobile to favor the usual explanations.

Figure 6 shows the Inn River near Saint Moritz. Figure 7 shows a very pronounced meander, formed by the erosion of the left bank of the Durance River above the Brillanne-Oraison Bridge. Traces of a similar meander which formerly existed in the right bank can also be seen.

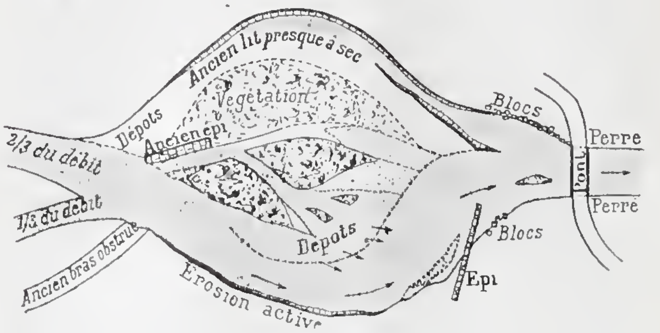


Fig. 6—Plan of the Inn Near Saint-Moritz.

Without doubt, in these two last examples, the obstruction of the bed by gravel deposited just above the obstacle helped to throw the current toward the banks and increased the tendency of the river to bend. This obstruction is the only cause of erosion in periods of low water when the river is shallow and the pressures are small. But it is not sufficient to explain a meander which curves through an angle of more than 180° like the one in Fig. 7.

It appears therefore that with a stream as with the wagon train of Fig. 2, a local resistance develops a tendency for the river to bend laterally upstream, or in other words a tendency to meander, because of the compression between this resistance and the inertia of the mass above.

On a smoothly flowing stream, this cause works alone at first and is helped by centrifugal force only after the bank has become curved. On a rapid river it is assisted by the stoppage of the channel with gravel deposited above the obstruction.

Successive Meanders.—Imagine, for a minute, a straight stream with a constant slope whose bed is being eroded.

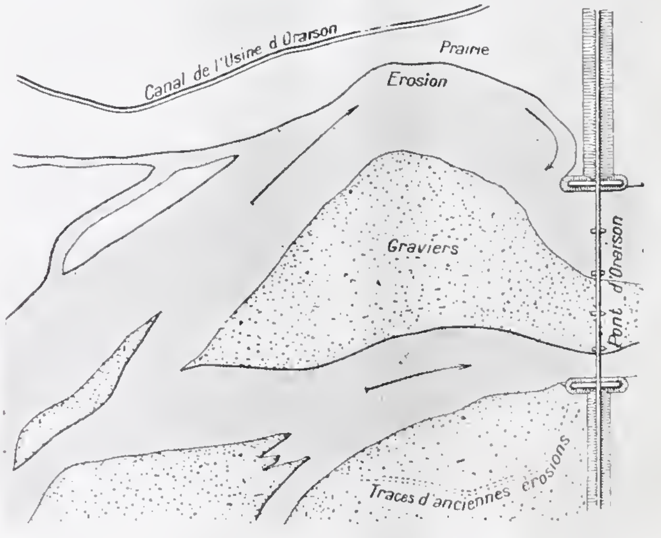


Fig. 7—Meanders of the Durance Above the Brillanne-Oraison Bridge.

The erosion of the bottom will not be uniform throughout. Hollows are dug in some places and other parts are filled in according to the relative solidity of the soil and the chance inequalities in the velocity of the water. After a while the bottom will be composed of a series of ridges and hollows.

Each bridge will form an obstacle and, according to the conditions of the preceding paragraphs, will create a tendency to lateral deviation in the region above; that of the hollow.

Figure 8 is a diagrammatic plan and profile showing these conditions.

Everything combines to develop this formation. The eddies which form at the curves (where the velocities at different parts of the cross section vary greatly) are favorable to erosion and the excavation at the concave bank is increased in depth and size by the transverse component, the eddies, centrifugal force and finally by the narrowing of the channel because of deposits along the convex bank. At the same time deposits form on the ridges or these causes disappear.

It is easy to recognize this formation in a river flowing through a valley whose soil is everywhere the same. Here the ridges are formed at more or less regular intervals according to the manner in which the bottom is eroded and the meanders take a uniform serpentine shape.

In other cases, these ridges may be formed by the material brought down by tributaries and are consequently more irregular. This is the case with the Theiss River, often cited as an example of meanders, for its length measured along the stream is more than twice the distance from source to mouth in a straight line. The Theiss has several tributaries, rising in the Carpathians,. which carry such great quantities of silt that the stream bed has been displaced laterally about 62 miles (100 kilometers). It is probable that the deposits of silt at the mouth of these tributaries have been the cause of such an unusual meander.

Conditions Unfavorable to Meanders.—This case is analogous to that of the wagon train whose speed is increasing as in Fig. 3. Figure 9 shows, at low water, the mouth of a canal discharging into the Moselle (same as Fig. 4). The low water in the river increases greatly the velocity of the water in the canal. The current of the canal tends to leave the concave bank of the canal in spite of the short radius of the curve exactly as the train in tension tends to straighten out.

Winding Streams with Steep Slopes.—In this type of river, the formation of meanders by "bending" takes place only when the water is at mean height. During periods of low water, the stream flows in a bed much too large for it and encounters deposits of gravel left by the last flood. It finds its way through channels dug by the floods and is displaced primarily by the debris in the river bed.

Summary and Practical Deductions.—A river tends to form a meander, when the velocity is decreased either because the slope becomes flatter or because of a resistance down stream such as a narrow gorge in the river bed.

This tendency is sometimes attributed to deposits of gravel, but it is more often due to the resultant of the force developed by the resistance and the inertia of the flowing water.

The curve, once started, is increased by centrifugal force, eddies in the curve and the deposit of material from the bottom in front of the obstacle.

Therefore, when locating a bridge or other structure creating a resistance the erosion of the banks as well as the effect on the flood water level should be considered. The only practical guide in this case is what is happening elsewhere on the same stream.

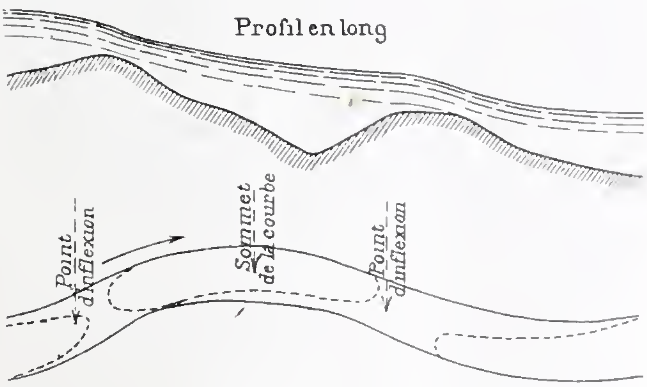


Fig. 8—Influence of Ridges.
(The dotted lines are the curves of equal depth.)

The repetition of this phenomena in a stream whose bed is composed of a series of transverse ridges will cause a series of meanders with plan and profile as shown in Fig. 8.

The shore protection does not have to be continuous but may consist of submerged piers, spaced at intervals, which may be compared to fixed points so arranged along a bar as to prevent its bending.

In the regulation of rivers, the question is often raised as to whether the new course should be straight or curved.

From what precedes, it can be seen that a straight channel would decrease the erosion and consequently there is nothing to prevent its use. It is very common in Switzerland.

However, from the point of view of navigation, the straight channel may be criticised because it increases the slope and consequently the erosion of the bottom of channel. On the Rhone (where the piers are used to regulate the existing channel rather than correct it) it is stated that a channel with a well defined, long radius curve is more easy to maintain than a straight one because, during the low stages, the water in a straight channel is divided up into several small streams by the irregularities of the bottom.

When the slope increases downstream the river's tendency to bend is replaced by a tendency to straighten its bed. The main current leaves the concave (exterior) shore of the curve and, in spite of centrifugal force, establishes itself on the convex (interior) shore.

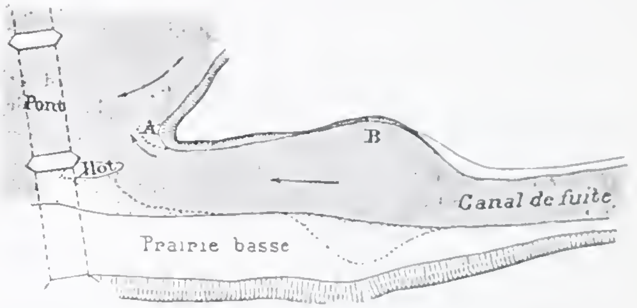


Fig. 9—Outlet of the Canal Flowing Into the Moselle.

The same thing occurs during a flood but the obstacles change in relative importance so that, in some cases, the variations in the slope may be reversed. Then the current digs against the concave bank and forms a ditch which, at low water, may give rise to an island or a dead arm.

In torrential water courses, the location of the main current near the concave bank and the presence of large logs on the convex bank is not sufficient reason for neglecting the foundations of any structure located on the convex bank. These logs were probably brought down by an exceptional flood followed by the present course. Another great flood may wash away the entire convex bank and form a new chanel.

Protection of River Banks

A writer in the Schweizerische Bauzeitung calls attention to the need of guidance as to the best means of protecting the banks of rivers. Technical opinions differ widely. One expert will consider the use of fascines and a facing of dressed stone essential; another will advise the use of rough stone blocks merely laid at random on the bank. Besides these there are the new methods of using reinforced concrete slabs and wire netting. The collection of numerous observations shows that the erosion increases, firstly, with the hydraulic gradient of the water, and, secondly, with its depth, and that it is the same for all cases in which the hydraulic gradient is multiplied by the depth is a constant. This constant multiplied 1,000 may be designated the erosion factor, and represents the action upon the bed of the river or stream, and also necessarily upon the banks and any protection which may be placed thereon.

After describing the various actions of the water, the author refers to the constant described above, and states that its value lay between 1 and 300 in a large number of cases of which he had collated the data. He has arranged these in two tables in the form of groups, and gives sketches representing the precise type of protection which has been found adequate for the banks of rivers having constants included in a given group. The first group, for example, includes all cases where the erosion factor has a value from 1 to 5, and here the protection may vary from nothing to a thin covering of loose stones, the bank having a slope of 1 in 2. The protection increases until from 20 to 30, one of large loose stones or dry walling is used, and this ends the first series. The second series comprises factors from 30 to 300, and for the last the banks were protected by very large granite blocks laid with dry joints, and the bed was covered with large pieces of rock. The hydraulic gradient was 200 per 1,000, and the depth of water 1.50 m.

Sewage Treatment Works of Birmingham and Utilization of Sludge

By JOHN D. WATSON,

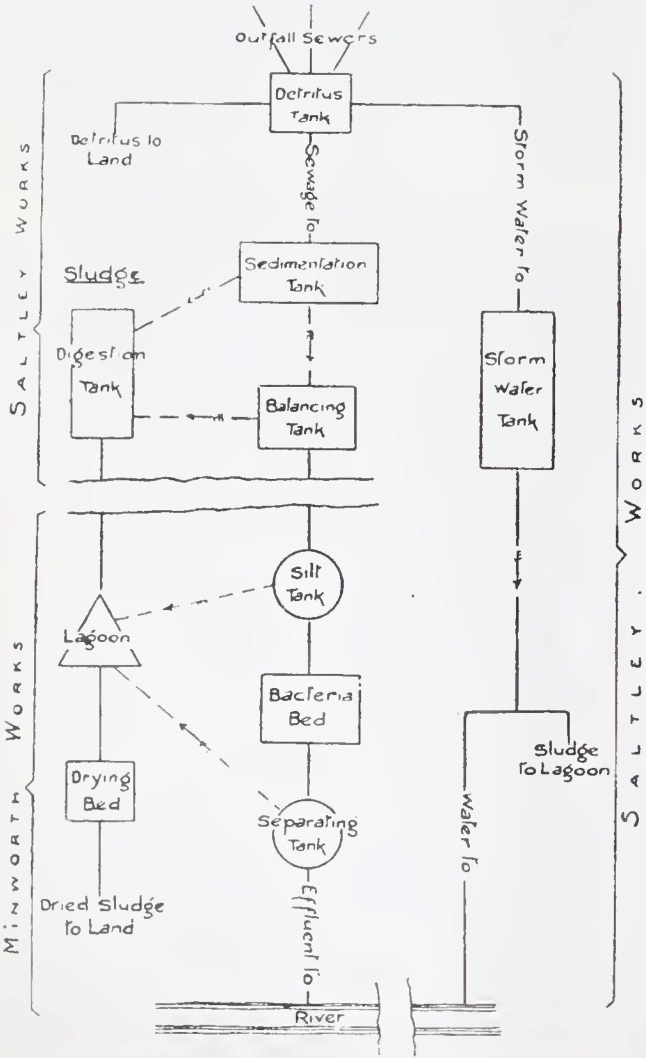
Engineer to the Birmingham Tame and Rea District Drainage Board.

From the Surveyor, July 4, 1919.

With the idea of carrying on the functions of oxidizing the liquid of sewage and the septicization of sludge simultaneously, Dr. Imhoff patented about 1904, and in German fashion boomed, a 2-story tank, which had the Travis hydrolytic tank for its prototype. The lower chamber of this tank is for fermentation, and the upper one for sedimentation. The Birmingham plan provides two separate shallow tanks, one placed alongside the other, to do the same work:

Birmingham's Method.—In comparing the two, it is claimed for the Birmingham method that the cost of construction is less; it is better under control; the results obtained under normal conditions equally good, and under abnormal conditions—such as obtain in time of rainfall—much better. Operating costs of the Birmingham method are greater than by the Imhoff method, but the latter is distinctly inferior when large quantities of antiseptic substances like gas tar arrive unheralded at the outfall works. It is desirable to isolate highly antiseptic matter instead of automatically distributing it over the whole surface of the fermentation chamber, or lower story of the Imhoff tank, where it tends to inhibit the action of the anaerobic organisms upon which the success of the process depends.

There are no doubt advantages and disadvantages based upon physical and topographical circumstances pertaining to both methods which an engineer must appraise in determining the design most suited to individual cases; but the author maintains that the shallow flat tank has more to commend it than the other.



Layout of Sewage Purification Works of Birmingham, England.

A marked feature of the Birmingham installation is the temporary character of the sludge digestion tanks, many of which are formed by a combination of excavation and embankment; the material employed to make the latter is composed chiefly of engine ashes laid on the soft material from the excavation. No lining of flagstones or inside coating of any kind is given to these improvised tanks, the sludge itself having been sufficient to seal all the interstices of the ash embankments. These tanks or lagoons are sufficient to effect the main objects in view, but they do not admit of the advantages of quick and thorough emptying and refilling associated with well-built vertical sided tanks. Still, when cheapness of construction is essential as, for instance, when one is experimenting, this form of construction has much to commend it; indeed, if the Birmingham installation had had to be designed with the view of obtaining Local Government Board sanction to a loan, the probability is that it would never have been built, and the gigantic experiment which is about to be described would never have been made.

After the inflowing sewage from a population of about 750,000 persons passes through the detritus pit, from which the heavy solids are dredged by an electrically-operated dredger, it flows through the five sedimentation tanks working in parallel and subsequently through what is called a balancing tank. Each of the former has a capacity of slightly more than 1,000,000 gal. and the latter 7,000,000 gal., together 12,500,000 gal., or about half the dry-weather flow coming to this the main outfall of the Drainage Board's main sewerage district. Each 5,000,000-gal. sedimentation tank is cleaned every week, and the balancing tank, which is run in series with them, less frequently.

The crude sludge—29.5 per cent water—arrested in the Saltley sedimentation tanks alone amounted to 1,523,000 cu. yd. during the past four years, or an average of 380,750 cu. yd. per annum, the whole of which was transferred to 39 sludge digestion tanks or lagoons possessing a total capacity equal to 28,250,000 gal.

The total dry solid matter removed from all tanks at Saltley, etc., outfalls, including Minworth tanks, in the four years 1915-1918, amounted to 110,000 tons or 75 tons per diem, all of which was transferred to the sludge digestion lagoons.

The density of the sludge removed chiefly depends on the frequency of the cleaning operation. During 1915 these tanks were emptied once in two or three weeks, when the average water content of the sludge was 87 per cent, whereas the weekly cleaning during the four years under consideration yielded sludge with a water content of about 92.5 per cent. Theoretically, the more frequent the emptying operations the better, but economy suggests a curtailment of the operation when temperatures are low. When temperatures are high there should be frequent cleaning, and the strictest avoidance of obstructions in the sewers should be encouraged if objectionable odor is to be reduced to a minimum. This becomes even more imperative as the area of a drainage district increases.

Sludge Digestion at Birmingham Plant.—It has been shown that with care the putrefaction of the liquid can be prevented, but the successful digestion of the sludge has proved to be a more difficult problem; still, with accumulated experience and the expansion of the tank area, the operations at Birmingham have been conducted with greater ease, economy and success as time went on.

The digestion tanks used at first consisted of an existing installation of 20 tanks, 16 of them with an aggregate capacity of 4,539,500 gal. and four of them with an aggregate capacity of 2,723,680 gal., all so thoroughly well built and equipped with emptying arrangements that they are easily the best of the installation of 39 tanks.

For the first two years the digestion operations were conducted in two stages in this installation of 20 tanks. The 16 tanks were used for primary digestion and the four larger ones for the secondary digestion. Two stages were adopted, as it was found in the very early days that vigorous fermentation was the better maintained thereby and tank space was saved to such an extent by pumping from one tank to another that the second pumping was economical when compared with the prospect of an increased capacity; it was soon discovered also that inoculating raw sludge with ripe sludge thus obtained from the secondary tanks had an excellent effect upon the "speeding-up" process. Further, temperature was too obviously a beneficial factor in the success of the process to be ignored.

The following mode of operation was adopted at the beginning of 1912 and has been continued ever since: In cold weather the sludge is transferred from the particular sedimentation tank whose turn it is to be cleaned out into the selected digestion tanks (generally five or six in number) by the main set of pumps; simultaneously some of the ripest of the available sludge is pumped by a small pump into the same delivery main in the proportion of 1 to 4, thus inoculating at the earliest possible moment the fresh sludge with the fermentative organisms; in addition, steam from one of the Lancashire boilers is injected into the delivery main to produce temperature conditions most favorable to fermentation. In moderately warm weather steam injection is abandoned, and during the heat of summer neither inoculation nor steam injection are resorted to. The biological factor governing the digestion process must necessarily be somewhat complicated, and it is only by the most careful observation of the conditions which bring about the right balance of living organisms that success can be achieved.

Analyses.—The following tables of analyses indicate two different sets of conditions, Table A where the fermenting mass was very offensive, and Table B where the vigorous fermenting mass was quite inoffensive:

TABLE A.

		Total counts. Organisms per c.c.
Gelatin-Peptone-Bouillon at 20° C	Mean	24,000
Agar-Peptone-Bouillon at 37° C	Mean	130,000,000
Coli group		7,000
Proteus group (including Enteritidis sporogenes)		100,000
Denitrifiers		500
Fat-splitting organisms		10,000
Cellulose		100,000

TABLE B.

	Total counts	
	Aerobic. Per c.c.	Anaerobic. Per c.c.
G.P.B. at 20° C	52,000,000	15,700,000
A.P.B. at 37° C	5,000,000	3,000,000
Coli group	60,000	
Proteus group	100,000 at least	
Denitrifiers	100,000 at least	
Fat-splitting organisms	100,000 at least	
Cellulose organisms	50,000 at least	

Having obtained the right bacterial balance, so to speak, the aim is to maintain it. What looks like an inexhaustible volume of sludge, which constantly varies in character (about 1,000 tons per day), is drawn to a locality literally surrounded with dwelling-houses, factories, etc., and formerly gave rise to loud and serious complaints. Now, this large mass of foul material is treated on the same site without any offense whatever.

Variation in the character of sludge is only to be looked for in a great manufacturing district where there are no restrictions on the discharge of trade waste into sewers; but these are sometimes very serious in their consequences, as when large discharges of tarry products from coal, water, or producer gas-plants suddenly appear.

The saving factor in the situation is the system of separate sedimentation and separate sludge-digestion tanks, so that, whether it is a sudden increase of volume due to rainfall or an overpowering mixture of antiseptics, the large number of sludge tanks in all states of fermentation renders the scheme at once elastic and manageable. The capacity of the whole of the sludge-digestion apparatus is equal to 165,000 cu. yd. or 28,000,000 gal., which, with the present demand, means a time retention of between four and five months.

	Per cent.
Water	92.5
Dry solid matter	7.5
Specific gravity of wet sludge (estimated)	1.0256
Specific gravity of dry solid matter	1.50

and the average analysis of the dry solid matter is as follows:

	Per cent.
Matter volatile at red heat	58.5
Matter non-volatile	41.5
Total nitrogen	2.71

The fatty matter in the crude sludge varies greatly, the actual limits for the figures in the analyses made being from 16.86 per cent to 31.00 per cent, with an average of 22.20 per cent. These figures represent a total ether extract, but it is probable that about 2 per cent of this ether extract is resinous matter, and the real fatty matter will be represented by an average figure of about 20 per cent.

Those who see the Birmingham works for the first time are struck by the great distance (about 5 miles) which separates the sedimentation tanks from the bacteria and sludge-drying beds. In contemplating this it should be remembered that the Saltley section of the board's works was built more than 60 years ago.

Functions of Lagoons.—The improvised lagoons at Minworth, which form part of the installation of [illegible] tanks, are formed by surplus spoil from the bacteria-bed site and dry sludge from the drying-bed area, and they perform at least three functions

(1) They give time for the completion of the fermentation process.

(2) They permit, with almost no detriment to the installation, the admission of humus from the bacteria beds, flushings from tanks, and flushings from distributing pipes.

(3) They act as decanters of supernatant water

The first is, of course, the primary purpose of the lagoon Imhoff found that he required his fermentation chambers to be large enough to contain from three to six months storage of sludge. The author finds that the average requirement for the past four years has been equal to a storage of four months. It has been proved abundantly that sludge dries more readily when the digestive process has been carried to exhaustion before it is pumped to the drying area; hence the economy of ample tankage.

The second is a most important function. The so-called "humus" excreted from a bacteria-bed, like the sludge discharged from an activated-sludge plant, is a valuable fertilizer, but so far has not yet been utilized because of its "emulsive" character and the difficulty and expense of dewatering. When nearly 1,000 tons of it have to be got rid of each day the importance of dewatering cannot be overestimated. To pump it back to the beginning of the process (the detritus pit) is a practicable solution in most cases, but not when it has to be forced through 5 miles of pumping main. Mixing it with the sewage as it entered the silt tanks just before spraying it over the bacteria beds was tried, but was found impracticable owing to the fibrous growths which were introduced into the distributors. Allotting a lagoon to itself with the view of trying to separate solids from liquid by mechanical action alone was not a success, and of all the various proportions of humus and ripe sludge mixtures made with the view of encouraging separation, the best result was obtained where the smallest quantity of the former was mixed with the largest proportion of the latter. This is understandable when one remembers that the "humus" contains 5 to 6 per cent of nitrogen, and the oxidized sewage effluent conveying it has in its composition a sufficient quantity of nitrates to arrest putrefactive tendeucies. How long this humus emulsion will remain a jelly it is difficult to say, but there are samples at the works which still retain that jelly-like character after exposure to the atmosphere for six years.

The third is not the least important function of this lagoon. Water rises to the surface when fermentation is exhausted, and frequently when it is quiescent, when it may be decanted direct to the filter-bed. When one remembers that by reducing a 90 per cent to an 80 per cent sludge one gets rid of one-half of its water content, the importance of decanting as much liquid as possible is evident. It has also been proved that additional advantage is gained by providing deep lagoons, thus supporting Mr. A. J. Martin's theory that the deeper the tank the denser the sludge obtained; at the same time the benefits in this respect must be measured by the degree of emulsification obtaining.

The rotted sludge or residuum of the fermentation process is pumped direct to the drying-beds, which are in the immediate vicinity. They consist of plots of engine ashes 150 ft. square, and have a total area of 51 acres. All the plots are under-drained with 4-in. agricultural tile-pipes in herring-bone fashion toward a main leader which conveys the drainage to a well, whence it is pumped with water decanted from the lagoons to a percolation filter made for the purpose. Each drying-bed is formed by earthen banks about 2 ft. high The area is provided with a system of permanent 2-ft. gage tramways—laid to suit locomotive haulage, both steam and electric battery locomotives—and provided with conveniently placed turnouts and crossings to allow temporary rails to be laid through the beds for the collection of dried sludge.

The time required for drying varies with the weather, but in dry weather it quickly cracks and admits air. When it has become sufficiently dry to be lifted in lumps it should be conveyed to the tip, as it is troublesome to the workmen when it gets into the dry-as-dust state; indeed, eye protectors have had to be provided in such cases. The embankments, which are being formed of the dry sludge, are about 15 ft. in height When the lumps are tipped over the embankments the drying is completed, and the estimations for calorific value dried at 212° F. give an average of 4,500 B.T.U. or something similar to the calorific value of ordinary house and shop refuse as burnt on a destructor.

Costs.—It should be clearly understood that this process of sludge treatment is put forward as a complete process in itself, just as the Imhoff tank process was put forward by the German engineer, but without, in this case, any suggestion that the effluent from the sedimentation tank could be discharged into a stream. It effectually converts an exceedingly offensive colloidal mass of sewage into a dry substance, which might be kept in one's office for years without giving off more odor than would garden soil in similar circumstances. This conversion is accomplished without nuisance at any stage, and, judging by pre-war costs, the expense is similar to that incurred by London and Manchester. In a report which the author submitted to the Drainage Board in June, 1914, comparative costs were given as follows:

	Per ton.
London	5.6d
Birmingham	5.7d
Manchester	6.9d

The figures for cost given by the Royal Commission on Sewage Disposal are as follows:

	Per ton. (90% water).
Sea disposal	4.1d to 6.9d
Trenching in soil	4.0d to 7.0d
Pressing (for large towns)	7.7d to 12.6d
Pressing and burning	18.0d

Comparing sludge digestion at Birmingham with these figures, and assuming a wet sludge containing 90 per cent water, it is approximately 5d. per ton.

Cost figures are bound to vary, and in comparing sludge costs care should be taken to see that the percentage of water in the sludges coincides. Another statement showed the cost to be 6.3d. per ton of sludge (86.6 per cent water), made up as follows:

(1) Cost of tankage, digestion, and pumping to drying beds:

	£	s.	d.
Wages	1,622	10	0
Coal	710	5	0
Stores, etc.	90	9	0
Repairs, etc.	22	10	0
Water charges	75	5	0
	£2,520	19	0

The volume of sludge dealt with was 260,000 cu. yd. Approximate cost per cubic yard of wet sludge, 2.25d.

(2) Cost of drying sludge, lifting and carrying to tip:

	£	s.	d.
28,816 cu. yd. of dry sludge	990	17	7
Cost of 1 cu. yd. of dry sludge			8.3
Cost of 1 cu. yd. of wet sludge			2.5

By adding (1) and (2), wet sludge, 86.6 per cent water = 4.7d. per cubis yard, or 6.3d per ton.

That the scheme as illustrated at Briminingham is as perfect as it might be made the author does not claim. It began as an experiment, and has been extended from time to time always as an experiment. The great tanks and lagoons, with a total capacity of 28,000,000 gal., have been built in a temporary manner out of revenue as necessity has arisen, and the design or lay-out—apart from the biological side—if design it may be called, is obviously an improvisation to meet current requirements and to obtain knowledge rather than a consistent ideal based on some well-tested prototype. Indeed, our calculations were so far out of truth originally that at one time we hoped that by an intensive fermentation at Saltley the 20 brick-built tanks, which have a capacity of only 7,000,000 gal., would suffice for treatment of all the sludge arriving there.

Utilization of Nitrogen.—The adoption of the scheme was due to the impossibility of septicising sewage and sludge together without nuisance. It has accomplished what it essayed to do, thanks chiefly to the consistent work of our chemist and superintendent of works; but its final success is dependent upon the profitable utilization of the nitrogen, which, up till now, has been lost sight of in the predominating desire to get rid of sludge with a minimum of nuisance.

With the object of recovering from the dry sludge nitrogen and other products of distillation, a boat-load of it has been sent to the Saltley gasworks each week for some time. Absolutely trustworthy results will not be available until more producers are installed there; but the gasworks engineer, Mr. Chaney says, that he is willing to give 3s. 6d. per ton for it delivered in boat at the Saltley gasworks.

The fact that they are possessed of a plant capable of treating sludge for a moderate sum does not satisfy the Drainage Board that they have done all that they might to utilize the nitrogen and grease found in it to the best advantage. Some boards might say that they have done all that is required of them by controlling effectually an enormous potential nuisance, such as is represented by arresting from 300,000 to 400,000 tons of sludge and converting it into a non-smelling dry substance (which under no circumstances can be re-converted into malodorous sludge), without establishing a huge municipal trading concern for the recovery of waste products; but the Drainage Board realize the possibility of doing more than they have done, and further that it is their duty to do more if that is possible; and with that in view they entered into a contract with the Anglo-Continental Fertilizers Syndicate, Ltd., just before the war began, by which that company agreed to treat about one-fifth of the Birmingham sludge with the view of recovering from it both fats and fertilizers, but chiefly fertilizers. The outbreak of war upset the project for the time being, the Treasury absolutely forbidding the expenditure of money on work of this kind, with the immediate result of encouraging the gasworks experiments, which have turned out as well, and now that the war is over the company's plans are to be put into the hands of builders whose initial work is essential before the company can begin to fulfil their agreement.

The scheme put forward by the company is as follows: The sludge is warmed to a temperature of about 90° F., when a small amount of yeast (from 0.5 to 1 per cent) is added, and the mixture allowed to remain in suitable tanks for a period of 24 hours, provision being made to keep the mixture at the optimum temperature of 90° F. As the result, certain important changes take place in the character of the sludge—the particles coagulate into a compact mass, which separate from the water and rise to the surface, being buoyed up by the gases evolved from the ferment. The water is run off through perforated pipes which, while allowing the liquid to pass, holds back the thick sludge, and enables the separation of the water from the sludge to be effected easily and quickly, and with a minimum of labor.

Some changes other than physical are brought about by the process, and the colloids are affected to some extent, with the result that the sludge is improved for subsequent treatment. Fermentation reduces the sludge from, say, 90 per cent water content—which is the average of ordinary sludges—to 80 per cent, equal to the reduction of one-half the water content, thus reducing the cost of treatment. The operation being a static one, the cost of working is small. The heat used for warming the sludge is obtained from the drying process, and may be either furnace gases, or hot air and vapor from the dryers, which would be otherwise wasted.

The further treatment of the sludge depends to some extent on local conditions. Moisture may be got rid of by treatment in dryers heated by means of hot air, by direct heat, or in steam-jacketed drying-pans. It can also be reduced to about 50 per cent by an intermediate process of pressing in ordinary sludge presses, and the cake, after being broken into small pieces, finally dried to a moisture content of from 10 to 15 per cent. The product is reduced to a fine powder for easy application to the land; it is then in a suitable condition for further treatment if grease is present in sufficient quantity to justify its recovery.

International Exposition of Municipal Equipment.—An international exposition of municipal equipment is to be held in the Grand Central Palace, New York City. It will include all that pertains to the construction and proper management of municipalities—for water, heat, light, power, fire protection, health, education, policing, amusement and other departments. This exposition will be a permanent institution, and will be one of the eight or nine expositions which will make up the industrial trade mart of the Merchants and Manufacturers' Exchange, occupying the entire Grand Central Palace. The municipal exposition will be staged on one whole floor with 50,000 sq. ft. floor space. The Merchants and Manufacturers' Exchange of New York, which operates Grand Central Palace, is owned and controlled by the Nemours Trading Corporation, of which Alfred I. Du Pont is president. Miss Jeanne Carpenter, 405 Lexington avenue, New York City, is director of the Municipal Exposition.

Special Features of Carron Dry Dock

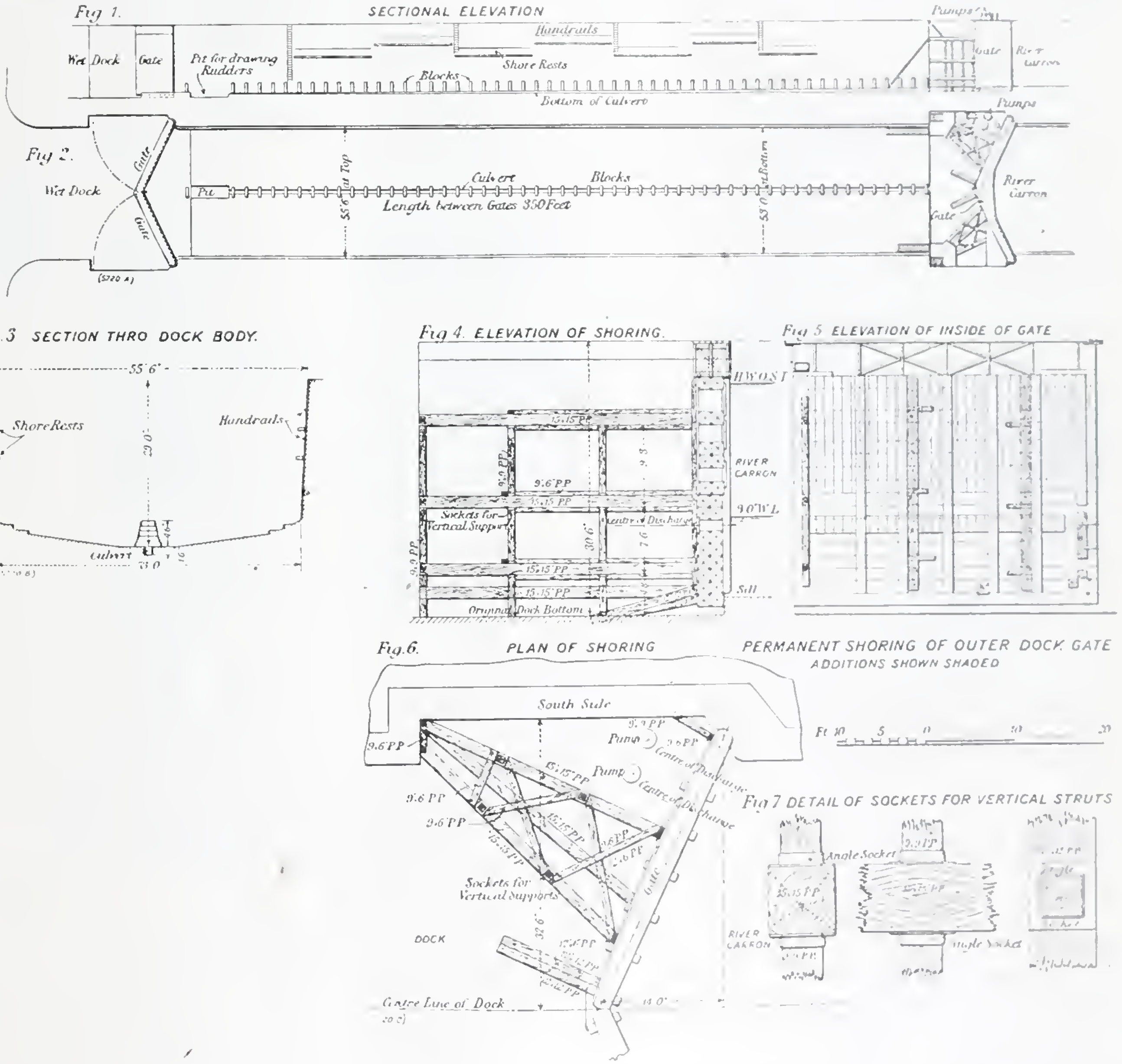
From Engineering, June 13, 1919.

An important addition has been made to the dry dock accommodation in the Firth of Forth by the utilization of a disused junction lock into the wet dock as Grangemouth. The utilization of the lock enables vessels up to 340 ft. in length between prependiculars and 50 ft. beam to be accommodated for repairs. This size practically covers all types of vessels trading to the ports on the Firth of Forth.

Figs. 1, 2 and 3 are respectively longitudinal section, plan and cross-section of the lock as finally completed. The success of the undertaking depended on the watertightness of the outer gate in the River Carron, and therefore open to the sea, to permit of it being made an efficieut permanent barrier to the sea. After months of labor the leakages were reduced to manageable dimensions, and kept under by temporary pumps, and the gate was found in good condition. Figs. 4 to 7, annexed, show this outer gate in sufficient detail to make a description unnecessary.

The second uncertain factor was, as to whether the lock bottom, after the mud was removed, would be found suitable to permit of heavy local weights, such as a ship being placed on it. These fears were found to be groundless, the bottom being fresh, clean and undamaged. The mud, of which there was 3,500 tons, was removed by utilizing a steam dredger, which conveyed the bulk of the silt to sea; the balance was manhandled after the water was fully drained off. The bottom of the lock was concave, as shown in Fig. 3, and a layer of concrete, 18 in. thick at center, was laid to make the radius less acute. An 18-in. waterway, Figs. 1 and 2, was formed under the keel blocks to give drainage to the pumps. The depth of this channel is 18 in. at the pump end of the dock and 6 in. at the other end. To give foothold at the extreme sides of the bottom, concrete steps were introduced and run throughout the length of the dock (Fig. 3). The dock sides being practically vertical, an arrangement of narrow, heavy staging with ladders adjacent has been fitted, at heights to suit vessels of different depths.

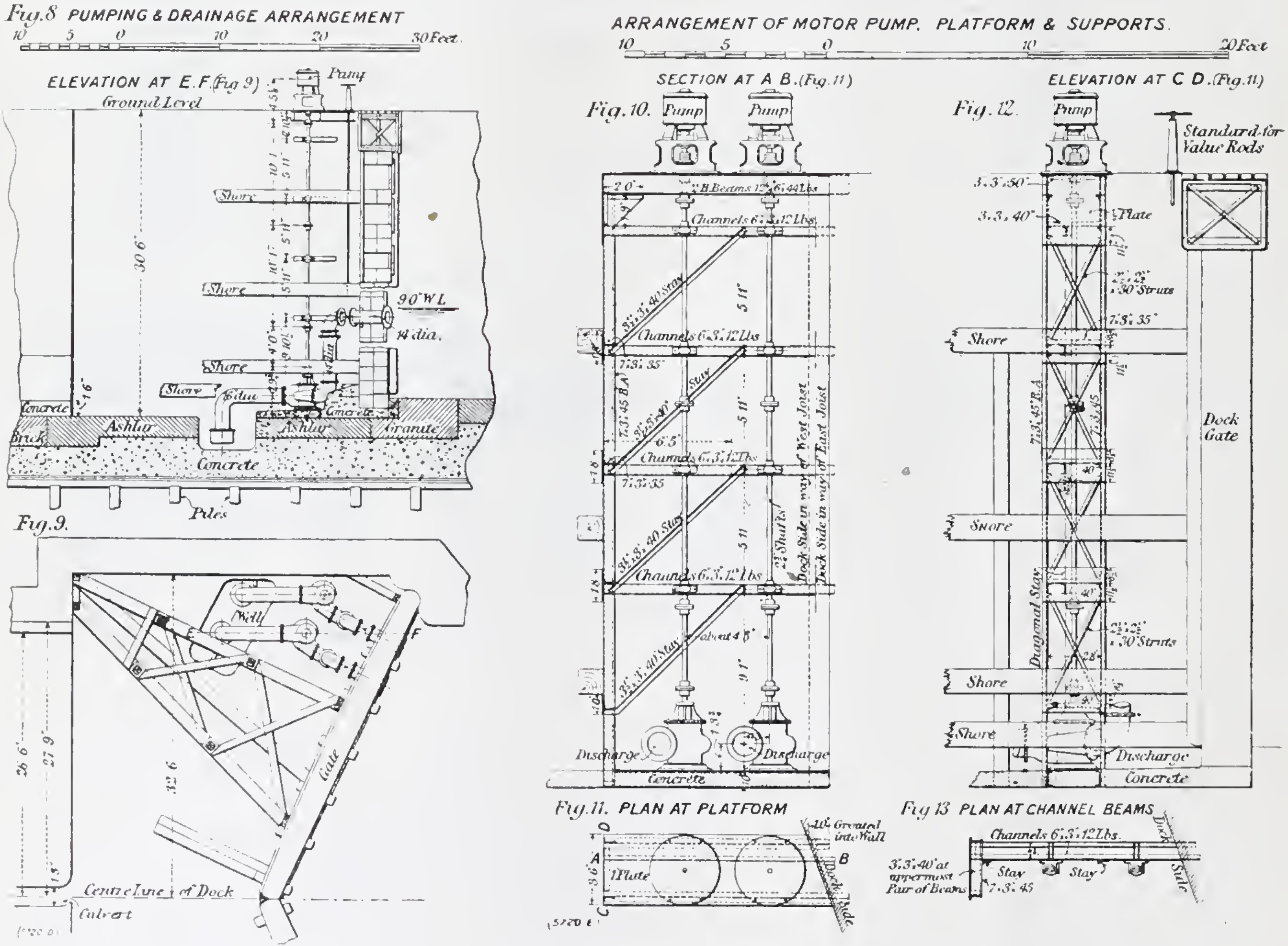
The pumping machinery is placed at the sea end of the dock, as illustrated on Figs. 8 to 13. It consists of two separate electric-driven centrifugal pumps by Messrs. Drysdale & Co., Yoker, Glasgow, each capable of delivering a mean quantity of 5,000 gal. per minute against an average head of 11 ft. when running at a speed of 750 r.p.m. The pumps are of the vertical-shaft type, placed in the bottom of the dock and driven through vertical shafting supported on lignum vitae bearings of the water-lubricated type. Each shaft is supported by a heavy ball thrust bearing mounted on a massive cast-iron stool, and provided with accurate means of adjustment for the setting of the impeller in the volute. Each motor is coupled to its respective shaft through a shrouded flexible coupling. The pumps are designed so that in the event of the head falling to zero, the overload does not amount to more than 2 per cent of normal full load. Thus the pumps are capable of running under all conditions with-



Figs. 1-7—Elevations, Sections and Details of Carron Dry Dock.

out attention to valves, etc. The motors are of the 3-phase slip-ring pattern suitable for 440 volts, 50 period, 3-phase supply. The machines are fitted with brush lifting and short-circuiting gear and are provided with attachments on the switch gear and the motor to prevent starting up in other than the proper sequence. When the pumps are required to deal with drainage water in which state they need to be primed, a small electrically-driven vacuum pump of the reciprocating type is brought into use. It is arranged so that it can take a certain amount of water through the valves. This small pump can be connected to any one of the main pumps by suitable change-over cocks. The whole equipment is designed with a view to attain maximum hydraulic efficiency, and it can be operated with unskilled attention.

While it is true that the lock is run dry by gravitation as the tide recedes, the water in the dock, even at low tide, can only fall to the height of the silted mud outside in the river. The pumps, therefore, have always this head to pump against, and the outlets were put through the dock gates at this level (Fig. 8) to reduce the load on the pumps during the bulk of the time they have actually to work in order to make the dock dry. As the entrance is from the wet dock, vessels can enter the dry dock at any time.



Figs. 3-12—Pumping and Drainage Arrangements of Carron Dry Dock.

The bottom parts of the keel blocks are of reinforced concrete, and the upper parts of oak, making a suitable combination ensuring strength and fixity of position with adjustment for height. No change of any kind has been made on the original flooding and emptying sluices.

Liverpool Municipal Farm Shows Profit.—The Liverpool, England, city council realized last year a profit of $4,600 from the farm at Carr Hall, Lathom, according to The Surveyor. The farm consists of about 80 acres and was originally purchased for £9,000 ($43,000) for the purpose of disposing of the city refuse. Local objection was raised, and it was decided to make use of it as a farm. Large quantities of hay, straw, oats, and potatoes have been raised, and in addition a small stud is maintained for horse-breeding, while in the summer part of the land is used for turning out horses in need of rest.

Wages of English Municipal Laborers.—The rates of pay of the labor staff of the Tilbury Urban Council, according to The Surveyor of April 25, 1919, were as follows: Sweepers—1s. 3½d. (31 ct.) per hour up to 47 hours, time and a half above 47 hours. Sundays and holidays double time. House Scavengers—1s. 4½ d. (33 ct.) per hour up to 47 hours, time and a half above 47 hours. Sundays and holidays double time. With bonus of 50 per cent on sale of all paper, rags, etc., collected in addition. Carters—£3 2s. ($15) per week of 54 hours. Laborers—1s. 4½d. (32 ct.) per hour up to 47 hours, time and a half above 47 hours. Sundays and holidays double time. Sewer Cleaners—1s. 5d. (32 ct.) per hour up to 47 hours, time and a half above 47 hours. Sundays and holidays double time. Lavatory Attendants—£3 ($14.50) per week of 54 hours. Road Tarring Laborers—1s. 4½d. (34 ct.) per hour up to 47 hours, together with 4d. per day dirty money, time and a half above 47 hours. Sundays and holidays double time. Housing Estate Handy-men—1s. 5d. (34 ct.) per hour up to 47 hours, time and a half above 47 hours. Steam Roller and Tractor Drivers—1s. 6½d. (37 ct.) per hour up to 47 hours, time and a half above 47 hours. Sundays and holidays double time.

Reinforced Concrete Grand Stand at Vienna.—A reinforced concrete grand stand with a seating capacity for 50,000 persons was completed last year for the race course at Vienna, according to Beton u. Eisen. The structure is in three sections, one 270 ft., a second 170 ft. and the third 417 ft in length, each section being separated from the others by lobbies 33 ft. wide. The roof of the structure slopes slightly towards the back, and projects at the front. Special consideration has been given to wind pressure in designing this roof. The various floors have been calculated to carry a load of 6¼ tons per square foot in case of panic. A test load of 10 tons per square foot was applied to the various parts of the building with satisfactory results. Other characteristic features are the wide stairways, the large space allotted to the paying booths and the ample accommodation for refreshments. The stand was commenced in 1912.

The X-Ray Examination of Metals

From Engineering, May 9, 1919.

It is not the object of this paper to describe the radio-metallographic installation used in the laboratories of Messrs. Schneider's Le Creusot Works, nor to explain the working of the apparatus. The apparatus used is the standard type plant manufactured by Messrs. H. Pilon, who are the licensees for the Coolidge tube in France.

The normal working current used is 4 milli-amperes with a spark gap of 25 cm. (10 in.), corresponding to a difference of potential at the terminals of about 120,000 volts.

Every precaution has been taken to protect the operator from the X-rays and secondary radiation.

The apparatus under discussion permits of the penetration of 40 mm. of steel. It is easily transported and may be installed in a workshop for the purpose of examining samples on the spot.

Results Obtained.—The following is a summary of the results obtained since the plant was installed:

(a) Researches into segregation and blowholes. Influence of aluminium on cast steel.

(b) Examination of steels containing different percentages of tungsten.

(c) Examination of compound metals.

The first application which suggests itself is an investigation into the heterogeneity of material (microscopic heterogeneity, of course). The diffusion of the X-rays, the consequent formation of secondary rays, and the grain size of the emulsion of the photographic plate limits the size of particle detectable to a diameter of not less than 1/5 mm.

This method was first of all applied to the investigation of blowholes in cast steel. Steel plates (railway fishplates 23 mm. thick) were cast in sand moulds without any special precaution being taken.

Application.—When a steel casting is made and it is desired to ascertain whether blowholes form in the metal when cold, a small piece of extra metal about 20 mm. to 30 mm. thick is cast in one with the main casting, this extra piece being examined under the X-rays.

When a new casting is being made in which, owing to the method of casting adopted, there is reason to suspect the existence of a defect at a particular point, this particular part is radiographed to ascertain whether the metal is sound. This may lead to a change being made in the method of casting.

Unfortunately there are limitations to this method owing to the lack of penetration of the X-rays. It is not possible to penetrate a thickness of more than 45 mm. of ordinary steel, and even for this thickness the time of exposure is considerable.

When the percentage of tungsten (which is of high atomic weight, viz., 182) is high, the plates are not so permeable to the X-rays as when this percentage is low.

When suitable illumination is employed these differences show up much more clearly on the negatives than on the positives. Thus three carbon steels, containing 0.6 per cent, 0.9 per cent and 1.15 per cent of carbon respectively give a radiograph in which are clearly observable the differences in capacity corresponding in these percentages. We have not been able to make from this negative a satisfactory positive on which the different degrees of capacity may be clearly distinguished.

It would appear possible, then, to apply radiography for the purpose of a rapid analysis in particular cases. If, for instance, carbon steel bars have been mixed up inadvertently with tungsten steel bars, they could be sorted out speedily by radiography, instead of a chemical analysis being necessary, which is always a long, delicate and expensive operation. The following might be the modus operandi in this case. Bars of unknown composition and a bar of the standard steel of the same thickness would be laid on a slab. A radiograph would then be taken and the opacity associated with each bar measured. The values obtained, compared against a chart drawn up from steels of known composition, would permit of a deduction of the nature of the various bars.

The method has also been applied to the examination of an ingot of a light aluminum alloy, 110 mm. in diameter. The radiograph enabled the ingot to be sawn through, without error, at the end of the blowhole, which was clearly shown in the photograph.

Conclusions.—In the present state of our knowledge of X-rays and their production, the application of radiometallography enables a visual examination to be made of ordinary steels provided their thickness does not exceed 40 mm. to [illegible] mm. This limiting thickness is reduced when the steel contains at least one constituent of higher atomic weight. It would be of inestimable value in metallurgy if ingots of 20 cm. thickness and upwards could be radiographed but unfortunately we have not yet reached that stage.

Still, every step in the direction of finding a director more sensitive to the X-rays than those that we already know (photographic plate, barium platino-cyanide screen, ionisation phenomena) will lead to progress in radio-metallography. Similarly, as the means of producing X-rays of high penetrative power are improved, it will be possible to increase the scope of X-rays in the examination of metals.

Salaries of Engineers

Letter in The Surveyor, June 27, 1919

There appears to be a growing tendency on the part of borough and urban district councils, and even county councils, to advertise for assistant engineers or surveyors without stating the salary offered for the appointments. Surely this is a method of advertising to be regretted. It appears to me very much like putting appointments up for auction—in other words, endeavoring to obtain a good man at the lowest possible salary. Is this an indication of meanness on the part of the councils concerned, or does it indicate an inability to decide the value to the council of the official required? Surely the straightforward way is to state the salary.

In my opinion, the average young engineer has a fair idea of his own "money value" judging by the experience he has gained, and is often guided in his choice, when applying for appointments, by the salary offered, the qualifications and experience demanded being usually the same, whether the salary offered is £150 to £350. I suggest that this is a matter to which the leading professional institutions might well give attention.

Another matter which occurs to me as being grossly unjust is the relative salaries paid by some councils to their surveyors and assistant surveyors. In a certain borough that I have in mind the surveyor receives the salary of, approximately £800 per annum—at present inclusive of bonus. The deputy surveyor receives £300, chief assistant £230, and four or five other assistants from £90 to £200 per annum. These salaries all include war bonus (£1 per week). I doubt if there is one man on the wages book of that borough surveyor's department who receives less than £2 per week, and many of the partly skilled laborers receive over £3 per week. The road foreman is paid £4 per week (or £208 per annum), and yet the chief assistant, who is a man of considerable experience under various councils, and an Assoc.M.Inst. C.E. (incidentally a qualification possessed by neither the surveyor nor deputy), is deemed to be worth only £4 10s per week. I do not question that the surveyor in this case deserves his salary, but surely there cannot be £500 per annum difference in value to the council between the work of the surveyor and his deputy, particularly when one is fully aware that the bulk of the "donkey work" of the department usually falls to the lot of the deputy surveyor and chief assistant.

When shall we see the leading institutions—i. e., the Institution of Civil Engineers and the Institution of Municipal and County Engineers—take up the case for any but the man at the top of the department? How often does it happen at present that the engineer or surveyor will not recommend substantial increases of salaries for his assistants because such recommendations, if persisted in, may endanger the increase he hopes for personally? I would like to think that the borough I have in mind is an isolated case, but I am afraid that many similar cases could be quoted. I suggest that it should be possible for the Local Government Board to fix a scale of remuneration for various appointments, based on the population of a town, or on the number of professional assistants employed.

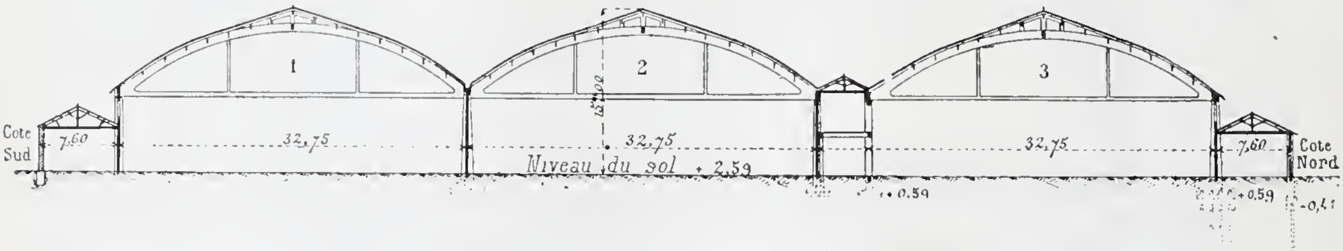
I have looked in vain during nearly 20 years' experience of the profession for some action to be taken in support of the young engineer and surveyor, and I suppose I shall still be looking when the time comes for me to retire from the profession (through old age, not through having made sufficient money to live on, unless the time comes when an Assoc.M.Inst.C.E. can demand better pay than a road foreman).

Reinforced Concrete Hangars for the Naval Aviation Center of Algiers

By E. CARRET.

From Le Genie Civil, May 24, 1919.

Until June, 1917, the Naval Aviation Center of Algiers was supplied only with Bessonneau portable hangars, made of a wooden framework covered with waterproof cloth, for housing the hydroaeroplanes which patrolled the coast. Because of the increasing necessity of protecting the transports traveling between Algiers and France from submarines, it was decided that hangars with a clear floor space 110 by 131 ft. (32 by 40 meters) should be built. The Service des Ponts et Chaussees, then doing a great deal of work for the navy, was asked by the Minister of the Navy to co-operate with the manufacturers and contractors of Algiers in building these important structures. The contractors were required to obtain all labor and material locally. Three types of construction were studied:



Transverse Section of Complete Shed.

(a) Masonry foundations supporting a steel framework.

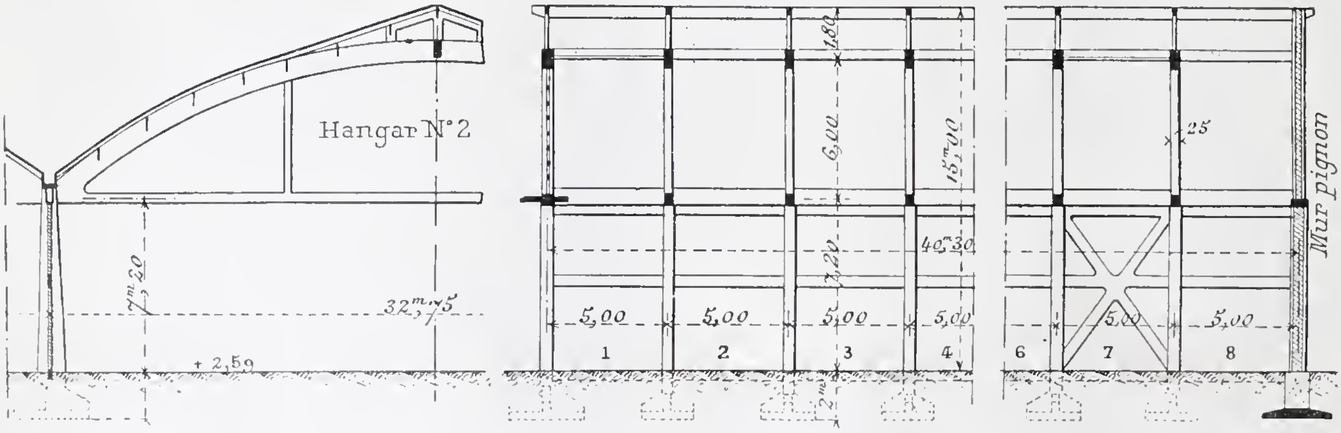
(b) Masonry foundations supporting a wooden framework.

(c) Reinforced concrete buildings with a tile roof.

The Minister of the Navy approved the project for reinforced concrete because the necessary materials could be obtained in the colony and because no skilled labor was required.

In August, 1917, a contract was signed by the Minister of the Navy and MM. J. Gregori et Fils, contractors for the construction of two regular double hangars. They are to be built according to the designs of MM. Pelnard-Considère, Coquot et Cie, of Paris. These two hangars were to be located near the existing hangars on the flats of the inner harbor of Agha, immediately south of the great pier completed at the outbreak of the war.

The foundations offered no special difficulties. The site was an old beach, covered to a depth of 6.5 to 8 ft. (2 to 2.5 meters) with the waste from a quarry.



Transverse Section and Part Longitudinal Section of Hanger No. 2.

The bottoms of the footings for the reinforced concrete columns were originally established at elev. + 1.92 ft. (+ 0.59 m.) but an examination of the excavations showed that, for many footings, it would be necessary to go deeper because of the poor quality of the soil. Part of these footings was therefore poured under water, using a concrete composed of 3.45 bbl. (600 kilogr.) of cement to 1.3 cu. yd. (1 cu. meter) of sand and gravel.

In calculating the size of the footings, it was assumed that the maximum load on the ground should not exceed 4,096 lb. per sq. ft. (2 kilogr. per sq. cm.), taking into account both the dead load carried by the columns and the wind load (150 kilogr. per sq. meter on the vertical elevation). In addition, the maximum load on the ground should not exceed 2,048 lb. per sq. ft. (1 kilgr. per sq. cm.) when only dead loads were considered.

On the footings of the first two hangars were placed three rows of reinforced concrete columns, spaced 106 ft. (32.75 meters), center to center. The distance between columns in each row was 16.4 ft. (5 meters). These columns were carried to a height of 23 ft. (7 meters) above the floor.

The two outside longitudinal walls and the partition separating the two hangars were built of a local brick 6 in. (15 cm.) thick. The space between two adjacent columns is divided into three panels by two reinforced concrete beams connecting the columns. These beams support the brick work.

The rear end of the hangars is an ashlar masonry wall whose height varies from 23 ft. (7 meters) at the columns to 49.2 ft. (15 meters) on the axis of the hangar. The front end is filled by the reinforced concrete roof truss, leaving underneath a clear entrance 110 ft. (32 m.) wide by 24.4 ft. (7m.) high for each hangar. This opening is closed by doors in panels 18 by 23 ft. (5.5 by 7 m.), each panel being a metal frame covered with galvanized corrugated iron.

It was originally planned, because of the span, to build the roof either as a barrel arch of parabolic section, stiffened by a few ribs or a roof of some other form supporting reinforced concrete slabs instead of tiles. This was not done.

The final accepted roof design called for a framework, including the purlins, of reinforced concrete, with a roof covering of tile manufactured in Algiers. The sheeting and rafters were similar to those used with a metal roof.

Besides insuring a very watertight roof, this construction gave a relatively light roof, thereby effecting an important saving in cement and steel.

On each column, every 16.4 ft. (5 meters), rests a reinforced concrete truss made up of a top chord in the form of a parabolic arch and a bottom chord to take up the thrust of the arch.

For the interior trusses the section of the top chord measures 9.9 by 27.5 in. (25 by 70 cm.) and the bottom chord 6.3 by 15.7 in. (16 by 40 cm.) To prevent the bending of the bottom chord under its own weight, two vertical members connecting the bottom chord to the top chord have been provided.

The arches are tied together by reinforced concrete purlins, 3.3 by 15.7 in. (10 by 40 cm.), spaced 7.4 ft. (2.25 m.) apart, by a ridge beam 5.9 by 59 in. (15 by 50 cm.) and by a strong beam located at the top of the columns.

To obtain a slope which would drain properly, the center part of the roof does not follow the outline of the arch but is lifted above it.

The wooden rafters are easily fastened to the reinforced concrete purlins by nailing them to wooden strips cast in the purlins.

The rainwater from the two interior slops runs into a reinforced concrete gutter, 19.7 by 7.9 in. (50 by 20 cm.), which discharges every 32.8 ft. (10 m.), through vertical pipes into a sewer laid along the base of the columns.

The end truss over the doorway is like the interior trusses except it has fifteen vertical members, instead of two, spaced 6.56 ft. (2 meters) apart. Half of the panels between these verticals are closed with a hollow tile wall, the rest contain windows. The lower chord of this truss is a foot bridge 6.56 ft. (2 m.) wide, which serves both as a support for the metal doors and a platform for operating the windows.

Salaries of English Engineers

Letter in The Engineer, July 4, 1919.

In view of the fact that a very large number of ex-service men are now training for the engineering profession, may I be permitted to call attention to the very poor prospects offered at the present time to fully trained engineers? For instance, the borough engineer of a large English town is advertising for an assistant engineer, and the salary offered is £150 ($729) per annum. Candiates for this post must possess a sound knowledge of building construction, surveying, levelling and drawing office routine, and be able to prepare specifications, estimates and quantities for sewer and roadwork. The salary stated is no more than that paid to builders' laborers in some districts, and is certainly less than that obtained by bricklayers, masons, carpenters, etc. Yet the advertisement says that preference will be given to candidates who are connected with the Institution of Civil Engineers!

Is it any wonder that the Appointments Department of the Ministry of Labor is so helpless in obtaining suitable appointments for ex-officers and others, when the public bodies of the country are setting such a low standard of remuneration for professional qualifications which take many years of hard study and considerable expense to attain?

MAURICE W. SALMON, Capt., R. E.

"Excessive" Water Consumption of 40 Gal. per Capita.—The water engineer of Swansea, Mr. Collinson, reports that the unmetered or domestic consumption for the March quarter this year averages 32 (Imp.) gal. per head per day, and this, compared with 59 (Imp.) gal. per head per day, which was the figure for the same area and corresponding quarter in 1917, shows a remarkable change in the state of affairs. "In total it means," Mr. Collinson continued, "that, without the least stinting of anybody's use of water, a quantity of 4,800,000 gal. per day now suffices in place of a former consumption of 8,850,000 gal. per day for domestic purposes. But, on the other hand, a further 2,000,000 gal. per day will have to be saved in order to reach the standard maintained by most well-conducted water undertakings. The fact that a neighboring water authority is actually a the present time spending a capital sum of £300,000 on a water scheme yielding a total supply of only 1,500,000 gal. per day, illustrates the enormous financial importance of what has already been done, and what still remains to be done, in the matter of cutting down the waste of water in connection with the Swansea undertaking." Mr. Collinson also alludes to the excessive consumption at Mumbles, amounting to 40 (Imp.) gal. per head per day, owing to defective service pipes. The Surveyor, May 9, 1919.

Cleaning Clay and Loam from Sands.—In a paper on "Sands for Concrete Making," read before the Concrete Institute P. G. H. Boswell stated that some method of "scrubbing" is the only way to clean ballast effectively from adherent clay and loam. On the other hand, the dust produced in the crushing of aggregate can easily be washed away. If the aggregate is required down to 50-mesh, an upward current of water at ordinary temperature of about 5 ft. per minute, or 1 in. per second, will remove all material smaller than this. If the aggregate is required to be not smaller than 20-mesh, a velocity of about 15 ft. per minute will remove the material not required. The objection to most sand washers in use is that the water first washes the dirty sand, and then, before it leaves the apparatus, is filtered again by the clean sand: much of the clayey and vegetable matter thus remains in the sand.

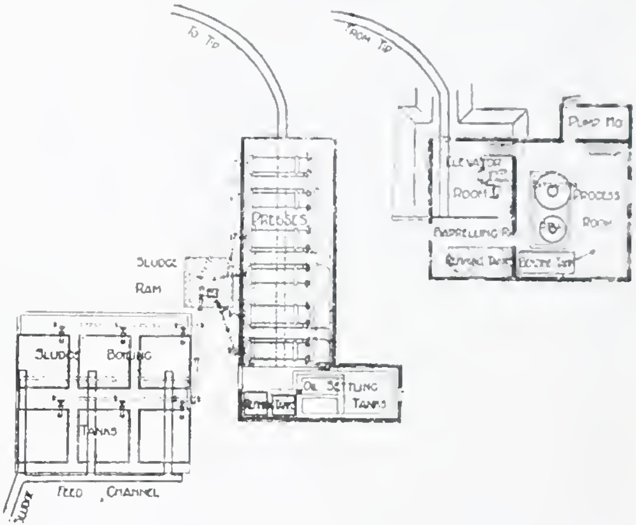
Extraction of Grease from Sewage Sludge at Morley

By F. TURNER,

Borough Engineer and Surveyor

From The Surveyor, May 30, 1919

The sewage was originally treated with lime, passed through settling tanks and on to filters. A certain number of sludge lagoons had been provided. The effluent from the works was satisfactory, but the amount of sludge produced was greater than was expected. It was estimated at that time that the dry-weather flow was 1,375,000 gal. per 24 hours, and the sludge produced in the settling tanks after the supernatant water had been drawn off was 550 tons per week. The original intention for the disposal of this sludge was to run it into lagoons, where it would be air dried, and then take it out to a tip and offer it to farmers. A certain amount was taken away by farmers at the beginning, but it was found to be unsuitable for use as a manure, and the dried sludge began to accumulate at an alarming rate. In about six years 12 acres of land had been covered with air-dried sludge to an average depth of 3 ft. In the meantime, at intervals, samples of sludge had been sent to analysts for examination in order to ascertain whether or not it would be worth while to attempt to extract grease; but the analyses showed that the amount of grease in the sludge did not average more than 16 per cent of the dry material, and it was not considered that grease extraction could be carried out without loss.



Layout of Sewage Sludge Plant at Morley.

It was, however, imperative that some other method of sludge disposal should be adopted quickly, as the tipping space was limited, and also large accumulations of this material in a tip were not at all desirable. In 1913 a small chemical laboratory was fitted up in the engineer's office with a view of carrying out systematic experiments on the sludge in order to find out whether or not it would be possible to extract any valuable content, and particularly to suggest some form of treatment which would convert the undesirable sludge into a desirable manure. The experiments carried out showed that if the grease present could be extracted and the moisture reduced the resultant material would have a ready sale as manure. Experiments on a large number of samples showed that the amount of free grease in the sludge was not greater than 16 per cent of the dry material, but in addition there was a considerable quantity of combined grease present in the form of soap—mainly lime soap—and the total quantity of grease calculated on the dry material was about 30 per cent.

It was then evident that grease could be extracted without much loss, and perhaps profitably particularly if the lime soap could be eliminated. Laboratory experiments were then carried out with a view of changing precipitants from alkali to acid, and as a result of these experiments it was decided to use sulphuric acid (brown oil of vitrol—80 per cent acid). It was found in practice that B. O. V. gave quite as good a tank effluent as the lime, and that the final effluent was as satisfactory, although the color was somewhat darker. The acid was also the cheaper precipitant. In addition, two very considerable advantages were gained—the quantity of sludge produced was reduced 25 per cent, while the total amount of grease was greater in the smaller quantity than in the larger amount produced by lime precipitation, the amount of grease varying from 30 per cent to 45 per cent of the dried material.

While using lime considerable trouble was experienced by the accumulation of large quantities of lime soap in the distribution pipes on the filters, and particularly on the surface of the filters, requiring the constant attention of men to clean the jets and considerably retarding the flow of water through the filters and therefore their capacity; deposits of calcium carbonate on the mouth of the jets also caused considerable trouble, as the deposit could only be removed by taking out the jet and steeping in acid water; even then it was difficult to remove. Since using B. O. V. these difficulties have disappeared, and the surface of the filters do not require nearly the same amount of attention.

It was evident now that the degreasing of the sludge would be a financially successful operation. Some experiments were carried out in the laboratory on the destructive distillation of sludge with a view of recovering, not only grease, but also the nitrogen in the form of ammonium sulphate, and leaving a carbon residue. While from the results obtained there appeared to be possibilities in this direction, there were certain difficulties in the way which would require considerable time to overcome, particularly mechanical difficulties in the design of retorts, and as this work was carried out during the period of the war, when it was well nigh impossible to obtain requisite plant for experiments on a larger scale, it was decided not to develop on these lines.

Although no such plant had been used successfuly on sewage sludge at that time, to the author's knowledge, the plant which seemed to be the most satisfactory one was the solvent plant worked with benzine as a solvent by which practically the whole of the grease in the sludge could be recovered. The serious obstacle that presented itself to the use of such a plant was that it was necessary first to reduce the moisture in the sludge to a 30 per cent maximum. This could be done by direct drying in drying machines, such as the Ruggles-Cole or Dublin driers, or by pressing and drying. From information obtained it appeared that to dry sludge with such a high percentage of grease in it as this one in driers was practically impossible, because of the grease carbonizing and firing the sludge in the drying process. It was finally decided to recommend steam-heated filter presses for the preliminary treatment.

A single filter press as a trial was first installed in July, 1915, and this proved an unqualified success; the results from it were quite equal to what the council had been led to expect, and other presses were added to deal with all the sludge produced, the plant being paid for out of revenue. The whole installation was completed in December, 1917. It was then decided to erect a solvent plant, but the difficulties in obtaining priority certificates and plant have been such that it has only recently been completed.

Treatment in Press-House.—The method of treatment in the press-house is as follows:

The sludge is fed from the reservoir along a wood channel, as required, into the sludge-boiling tanks. These are six cisterns, 12 ft. square and 6 ft. deep, made of wood. The sludge in the cisterns is treated with acid (B. O. V.) and then heated by means of steam, through 1-in. steam pipes, passing down the middle of each tank to the floor. Live steam is blown into the sludge for about four hours, which, in addition to heating it, acts as an agitator, mixing the acid with the sludge. The sludge is then run into the sludge ram and forced by steam from the ram into the presses. The most economical time for filling the presses is found to be 24 hours, during which time the sludge in the presses is steamed twice, for a period of 30 minutes each time, by means of steam pipes fitted at both ends of the presses. The yield of grease appears after about four hours from the time of starting filling, and the greatest yield is for a period of six hours after the grease starts showing.

The presses are fixed on supports 5 ft. 6 in. above the floor. There is a wagon road under the presses, and in emptying the cake is directed by means of chutes under the presses into the wagons and run to tip. The grease and water is conducted by means of a channel into a settling tank. The water runs away from this tank by means of a syphon pipe from near to the bottom, and the grease finds its way in a thin film over sills into one of the two smaller grease-settling tanks.

By means of a swivel elbow pipe the grease is taken from the surface and run into the grease ram fixed below the refining tanks, from which it is then ejected by steam into one or the other grease refining tanks. Here the grease is refined by raising it to boiling-point by means of a closed steam coil, and spraying with cold water, and, if necessary, adding brown oil of vitrol amounting to 2 or 3 per cent, and maintaining a brisk mixing for about four hours. The grease is then allowed to stand for about twelve hours; the dirt and water settle to the bottom, and are drawn off. The refined grease is then barreled.

There are six presses, and each press does five pressings per week

The steam for both the press plant and the solvent plant is obtained from two Cornish boilers, which were originally installed in connection with two compound horizontal engines to drive a sewage-screening plant and lime pans. The engines are now being used to drive a dynamo supplying current for electrical drives of machinery in the solvent plant house and for lighting.

It has been found that the sludge cake parts with moisture quickly simply by air-drying, and is sufficiently dry after being out about a month to be used as fuel in the boilers. The sludge cake has until recently been burnt in the boilers with about 3 tons of engine coal per week. This is sufficient not only to run the press plant, but to supply steam for a considerable amount of pumping which is carried out on the disposal works. The pressmen are at present working two 12-hour shifts per 24 hours. There are three men working as laborers in the press-house during the day shift, one man as pressman during the day, and one pressman on the night shift. This man is the only man employed during the night shift in the press-house.

It is proposed to start 8-hour shifts shortly, when there will be required a pressman for each shift and four laborers on one 8-hour shift.

Financial Position of Press Plant.—The amount of grease extracted by the presses averages about 5½ tons per week. The grease was sold throughout last year at £60 per ton. The sale price today is £45 per ton. The receipts and expenses from the press plant per week are as follows:

	£	s.	d.
Receipts—			
5½ tons of grease at £45 per ton	£247	10	0
Expenses—			
Haulage	1	7	6
Barrels	13	4	0
17 tons of coal at 26s. per ton	22	2	0
2½ tons B.O V. at £5 8s. per ton	13	10	0
Wages, including stokers	21	19	0
Filter cloths	30	0	0
Repairs	1	0	0
£3,200 at 6 per cent interest on cost of plant	3	10	0
	£106	12	6

	£	s.	d.
Receipts	£247	10	0
Expenses	106	12	6
Balance per week	£140	17	6

The grease produced has a sapouifiable value of from 50 to 55 per cent.

The woodwork and brickwork of this plant have been badly attacked by nitre cake, which it has been necessary to use in the absence of B. O. V. during the last three years. Nitre cake is an acid salt by-product produced in the manufacture of nitric and sulphuric acid. Its acid strength is about one-third that of B. O. V., though its action on most materials is more violent.

Extraction Plant.—It is found that the sludge cake after airdrying has a moisture content equal to about 28 per cent. The solvent plant deals with about 40 tons of the cake per week without further drying. This plant has only recently started working, and it is not possible to state definitely what charges it will be found best to work with or the time taken in treating each charge; but from the experience so far gained it is probable that the quantity of cake will be dealt with in six charges, and the time taken by one charge will be 22 hours. The pressed cake is taken from the tip in wagons into the elevator room, and is fed by hand into a cake-breaker. It is ejected from this machine into the foot of the elevator, which lifts it into the hopper fixed immediately over the extractor. The capacity of the hopper is exactly equal to the capacity of the extractor; there is a sliding door on the bottom of the hopper, and a hinged charging door on the top of the extractor. The extractor is a cast-iron vessel 8 ft. in diameter and 10 ft. deep, fitted with a discharging door at the bottom of the side at such a height that the treated material may be raked out into wagons. A false bottom of removable perforated cast-iron plates is fixed level with the bottom of the discharging door, and the perforated plates are covered with canvas, and another set of perforated plates of lighter metal placed over to hold the canvas in position and to carry the charge, the canvas acting as a filter for the solution of grease and solvent. Underneath the perforated floor are an open steampipe, a closed steam coil, and connections to the solvent storage tank and the still. There is a cast-iron pipe connection from the top of the extractor connecting with the main condenser. The benzine storage tank is fixed alongside the still; it is a cast-iron tank with a capacity of 1,500 gal., fitted with a gauge glass and connections to the extractor and separators. The still is a cast-iron vessel, similar in outward shape to the extractor, 6 ft. diameter and 8 ft. 6 in. deep, with connections to the extractor, a cast-iron pipe on the top connecting with the condenser, and a grease pipe connecting the bottom with the grease-refining tanks. The still contains an open steam pipe and a closed steam coil. The two condensers are multitubular condensers, each containing 330 sq. ft. of cooling surface, one working in conjunction with the extractor and the other with the still; they are arranged also for working, if desired, in series. The vapor passes through the tubes, and the condensing water which is tank effuent, is circulated by means of a Pulsometer centrifugal pump round the outside of the tubes. The condensed mixture of solvent and water passes from the condenser into gravity separators, one separator connected to the extractor condenser and the other to the still condenser, where the mixture separates because of the difference in specific gravity. The water is taken away by means of a syphon pipe connecting with the drain, and the solvent is automatically drawn off from the top and returned to the solvent storage tanks. There is a third auxiliary condenser connected with the separators, similar in all respects to the main condensers, only smaller, which condenses any vapors which have escaped the main condensers. It is essential that the condensers should be very efficient in order to prevent leakage of solvent.

Extraction Process.—The extraction process is carried out as follows: When the extractor has been charged with disintegrated cake from the hopper, and the doors made tight, a quantity of solvent—from 300 to 500 gal.—is run into the bottom chamber of the extractor from the solvent tank. The steam is turned gradually on to the closed steam coil, and the solvent slowly evaporates through the charge, passes into the condenser and back to the storage tank by way of the separators. A portion of the benzine condenses in the mass and so dissolves the grease. The dissolved grease as a grease-solvent solution at the same time continually passes from the charge through the perforated plates into the bottom chamber of the extractor, and is blown out by steam pressure into the still. The process is repeated until the whole of the grease has been dissolved out and blown off into the still. The open steam is then turned on in addition to the closed steam coil to drive off the solvent remaining in the extracted charge. The extracted material is ejected from the extractor and a new charge fed in from the hopper, which has been filled during the extraction process, and the process repeated. The grease solution in the still is subjected to heat by means of the closed and open steam coils until the solvent has been driven off, and the grease is then blown by steam to the grease-refining tanks, where it is refined as described in connection with the press plant.

The solvent used is petroleum benzine; the loss is about 90 gal. per week, or 2¼ gal. per ton of cake treated.

The material discharged from the extractor, containing not more than 4 per cent grease, is in a powdered state; in this form it is of value as a fertilizer. There has been already a considerable demand for it from manure merchants. The plant requires to work it one man as process man with the additional assistance of one man to charge the hopper, the workmen being at present on 12-hour shifts.

Expenses and Receipts of Extracting Plant.—The cost of the plant, with the building, is £5,000. The expenses and receipts per week on this plant are as follows:

	£	s.	d.
Receipts—			
5 tons of grease at £45 per ton	£225	0	0
16 tons of manure at 10s. per ton	8	0	0
	£233	0	0

	£	s.	d.
Expenses—			
Haulage	£1	5	[illegible]
Wages, including stokers	16	19	[illegible]
7½ tons of coal at 26s. per ton	9	15	0
90 gal. of benzine at 2s. 1½d. per gal.	[illegible]	[illegible]	[illegible]
Interest on cost of plant—£5,000 at 6 per cent	[illegible]	[illegible]	[illegible]
	44	[illegible]	11
Balance per week	£188	11	1

The total balance from the two plants per week is therefore—

	£	s.	d.
Balance from press plant	£140	1	[illegible]
Balance from solvent plant	188	11	1
Total balance	£[illegible]	[illegible]	[illegible]

General.—The total cost of wages on press plant and solvent plant, together with stokers' wages and cost of coal for pumping, have been included in the above statements, although the same number of stokers were required and pumping was carried out when lime was used as a precipitant. Actually the number of men employed on the works at that time to deal with the sewage and sludge disposal was exactly equal to the number of men now employed, including those working on night shift.

The yield of grease from the two plants given above may be varied as experience is gained in the use of the press plant as a drier simply. Until the solvent plant was put into operation the object has been to obtain the maximum yield of grease from the presses. Now any grease left in the pressed cake will be extracted by the solvent plant, and it may be found better to use fewer presses and shorten the time of pressing, so reducing the labor in the press-house and the cost of the press cloths.

Only one analysis has been made of the extracted material from the solvent plant, and that was from the first week's working. This will be improved in two respects—the amount of grease and moisture will be reduced. The analysis is as follows:

The sample contained in 100 parts—	Per cent
Water	39.28
Organic matter other than grease	37.88
Grease	3.80
Phosphates	trace
Silicious matter	11.89
Calcium sulphate, etc	7.15
	100.00

The organic matter contains—	
Nitrogen	2.36
Corresponding to ammonia	2.87

The makers of the presses were Messrs. Knowles & Co., Bradford, and of the solvent plant Messrs. J. F. Carmichael & Co., Liverpool.

It may be of interest to give an analysis of the crude sewage and the cost of precipitation. The following is the average analysis of six samples taken on consecutive days. Each sample is made up of 24 hourly samples, averaged according to rate of flow; Sunday is omitted:

Ammoniacal nitrogen	1.5[illegible]
Albuminoid nitrogen	1.4[illegible]
Oxygen absorbed (4 hours test with strong perman)	24.11
Suspended solids	72.50
Soluble solids	181.1[illegible]
Chlorine	13.6[illegible]

The amount of acid precipitant required to treat the sewage varies considerably according to the class of work engaged upon in the local factories; far more acid was required during the war period, and is now, than during 1913-14. At present 6 tons of B. O. V. are used per week at a cost of £32 8s. It is estimated from present experience that if lime were used the cost of lime alone, without mixing at the works, would be £26 8s. per week.

Method of Preventing Shanking in Hand Drill Steel.—In discussing a paper, "Economics in Hand Drill Steel," in the Journal of the Chemical, Metallurgical and Mining Society, H. A. Read said that one of the principal losses was due to the shanking of the steel under the blows of the hammer. By heating the end of the drill and staving it up so as to give the head a bulbous or pear shape and subsequently tempering it, the drill was provided with a head capable of resisting hammer blows without shanking. It appears that the head is so staved up that the least possible disturbance is created in the first instance in the molecular formation of the steel. Correct draw tempering then clothes the head with a fine coating of hard tempered steel—probably not much more than 1/16 in. thick—below which is a body of lower tempered steel. This body of lower tempered metal, increased as it is beyond the original section of the drill, provides a reinforcement which prevents the disturbance and disintegration of the molecules of metal which otherwise take place under impact.

The Wind Resistance on a Train

By C. F. DENDY MARSHALL,

From The Engineer, May 16, 1919.

In the case of a body traveling through a fluid at a high velocity, the resistance experienced depends on the shape to an extent that has only been realized of late years. In theory, at all events, a perfect "stream line" body should experience no resistance, except that due to skin friction.

It is obviously impossible to approximate at all to a stream line form in the case of a train, but that is no reason for going to the other extreme, and utterly ignoring the question of shape.

Little has been done to try and improve matters, except that about 25 years ago, on the South-Western Railway, Mr. Drummond made some of his smoke-box doors conical in shape, a plan followed on some continental railways, and that on the Paris, Lyons and Mediterranean, a wedge formation with the same object appears to have been aimed at. Neither of these efforts met with practical success, the theory of the air resistance to bodies moving through it being comparatively undeveloped, and the necessary experimental data lacking. The cone of the smoke-box door took the place of a flattened hemisphere of comparatively quiescent air which is pushed along in front of the ordinary door. So far as it may have encroached beyond that, it must have intensified the pressure on the outer part of the front. With regard to the French engine, merely substituting sloping surfaces for upright ones is an expedient that is of rather problematical value, and one which, under certain conditions of wind and speed, has the effect of increasing the side pressure on the rail.

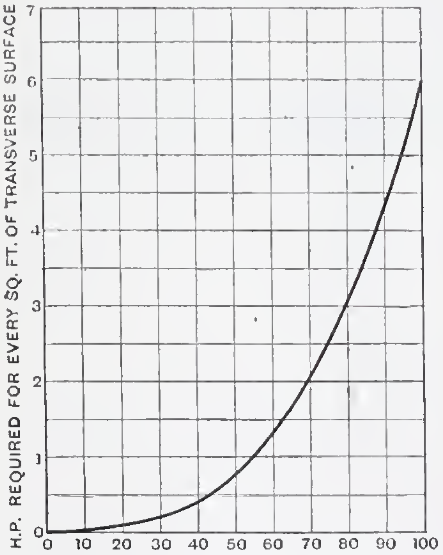


Fig. 1.

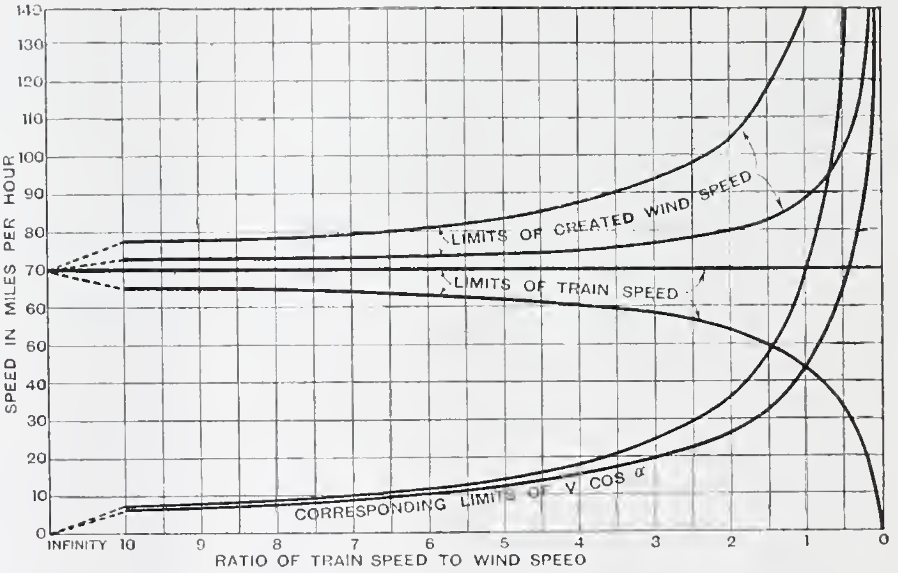


Fig. 2.

Thanks to the work which has been done in connection with aeronautics, it is now possible to take the matter up and study it on a scientific basis, with a promise of substantial improvement.

The importance of the front wind pressure on the engine is not fully appreciated. The horse-power required to overcome it increases with the cube, not merely of the speed of the train, but with that of what is called the "created wind," which in the case of an express train may easily exceed 80 miles per hour.

It may now be taken as established that, for speeds within, and even far beyond, the range of railway speeds, the resistance of the air to a surface moving normally to itself is represented by the expression KAV^2, where A is the area exposed, V the speed, and K a constant. If A is measured in square feet, and V in miles per hour, $K = .0033$.

The constant .0033 applies to the total resistance, and includes the now well recognized suction on the back of a moving body. For plane surfaces normal to the wind M. Eiffel found in his famous experiments that the suction accounted for ⅓ of the total. The frontal pressure alone may, therefore, be taken as $.0022\ AV^2$, and the horsepower required for every square foot of exposed surface is

$$\frac{.0022\ V^3}{375}, \text{ or roundly } \frac{6}{10^6}\ V^3$$

The value of this expression is shown by the curve in Fig. 1. At 60 miles per hour it is approximately 1¼ horsepower, and at 80 miles per hour 3 horsepower.

If we know the "all out" speed in a calm, say, 70 miles per hour, numerical limits can be assigned between which the speeds will lie for any ratio of train to wind speed. These limits are shown in Fig. 2.

Here V cos α represents the resolved part in the direction of travel of a wind blowing with velocity V at an angle α to the rails.

It will be readily understood without entering into calculation that the speed of the created wind creeps up as the strength of the natural wind increases, and that 80 miles per hour is quite a moderate figure to take for it, while Fig. 1 shows how sharply the demand for power runs up with any increase of speed in that neighborhood.

We now know fairly well what is the best shape for a body which is to be driven through the air at speeds of the order under consideration. The front should be quite "bluff" a sharply conical or wedge-shaped form not being at all the ideal to be aimed at. What is required is to eliminate every square inch of transverse flat surface that can possibly be dispensed with, smoothing off projections, and putting in gentle curves parallel to the natural flow of the air.

Reinforced Concrete Hydraulic Mains.—In a communication to the Société Technique du Gaz, M. Martineau describes the successful result which followed the emergency measure of constructing ten hydraulic mains in reinforced concrete, undertaken as the only possible course during the war, in consequence of the high price of cast iron and the delay in getting such work completed. The metallic reinforcement consists of a network of ¼ in. round iron wire formed in squares 4 in. by 4 in. The concrete walls have a thickness of 2⅜ in. The walls of the main rest on I-iron running the length of the retort-bench. The valve of the tar-outlet is let into the concrete. A rebate along the upper part of the main receives the cover, formed of a slab of concrete into which are set the inspection and cleaning boxes. Before being taken into use, all the interior surface of the main, as also the lower side of the cover were given three coats of hot tar. This was done in order to close up the capillary passages in the concrete, and thus prevent any action of ammonia upon the metallic reinforcement—the continuous flow of tar during the working maintaining this protective coating. The main was taken into use without any mishap in the way of expansion or leakage. Test pieces of concrete placed in it at the time of commencing operations, and examined six months afterwards, showed no sign of any action on the concrete by the ammoniacal liquor.

Traveling Crane of Reinforced Concrete

From Le Génie Civil, March 8, 1919.

The scarcity and high price of iron and steel since the war has caused reinforced concrete to be used instead of these metals in many unusual places.

This article describes a new use of reinforced concrete, namely, in the construction of traveling cranes for factories.

Because of the enormous demands of the reconstruction work for sheet iron, plates, flats and structural shapes, the Beccat Co. realized that the difficulty of obtaining these materials would continue long after peace was declared and has developed a satisfactory crane of reinforced concrete.

The development of this crane was carried out as follows:

1st. Experiments with the construction of cranes of several different types.

2nd. Experimental design of beams which would have not only the necessary rigidity but also sufficient elasticity to withstand easily the shock of sudden loads and to prevent the formation of cracks which might endanger the strength and durability of the crane.

3d. As a result of these experiments, to determine the distribution of reinforcing rods.

4th. To so connect the reinforcement of the main beams with the cross beams at the end, that the different members will act together as a monolith.

5th. To provide for easy mounting and dismounting of the driving mechanism.

The use of reinforced concrete for building cranes has the following advantages:

1. The substitution of ordinary bars for structural shapes.
2. Their construction at the factory where they are to be used, this construction being carried out simultaneously with that of the building, by the same contractors and, with the same materials. All of the mechanical and electrical equipment need not be brought on the job until the crane is ready to be operated.

The illustration gives a general view and the details of a reinforced concrete crane with a capacity of 6,600 lb. (3 tonne) and a span of 32.8 ft. (10 meters). The arrangement of the reinforcing in the main and secondary members is also shown.

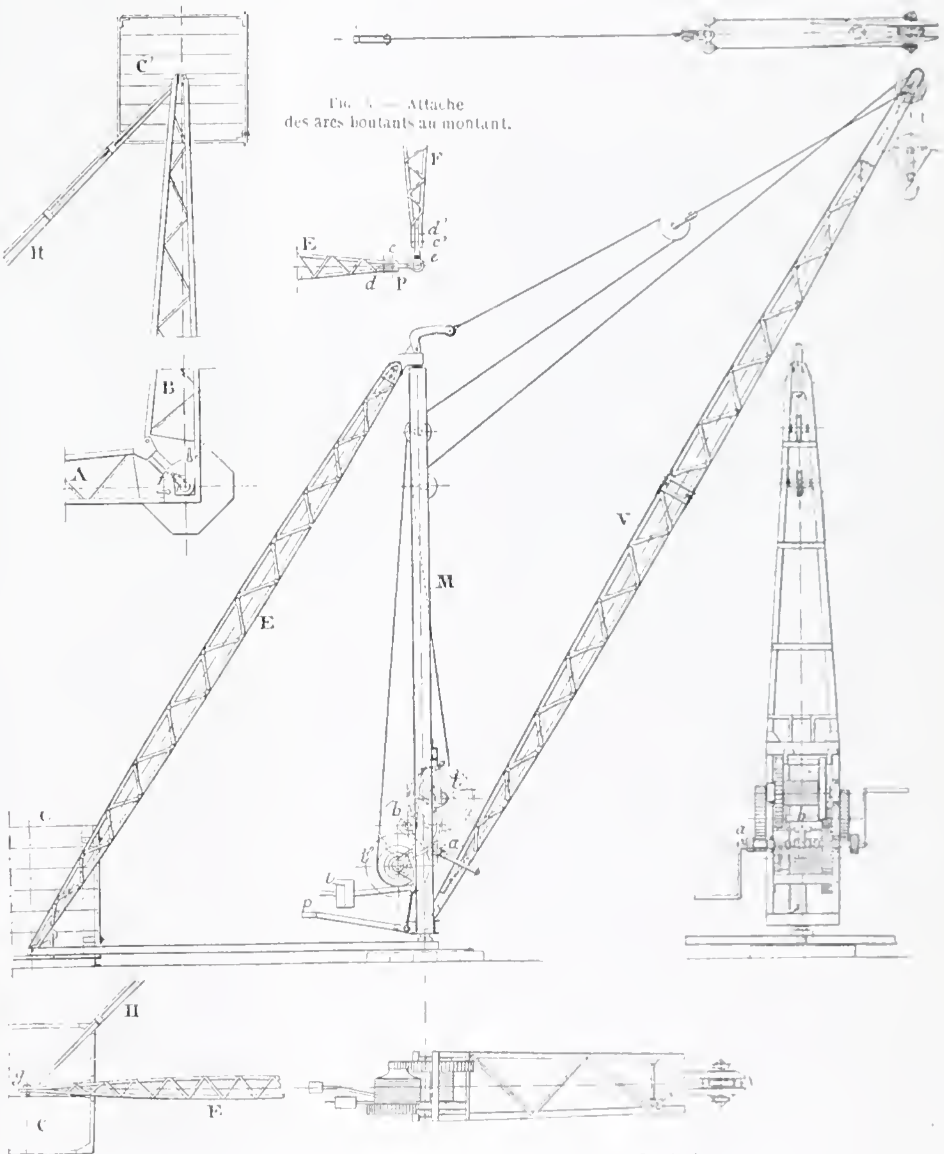
The rolling gear of the crane is removable and so attached that it can be adjusted to take care of any warping of the crane. The rollers and bearings as well as the drive shaft are all easily removed and replaced.

These cranes are constructed of a rich concrete, 2.3 bbl. (400 kilogr.) of cement to 1.18 cu. yd. (0.9 cu. meter) of gravel and 0.52 cu yd. (0.4 cu. meter) of sand. This concrete develops a crushing strength of about 780 lb. per sq. in. (55 kilgr. per sq. cm.) and a bond strength with the reinforcing of about 80 lb. per sq. in. (5.5 kilogr. per sq. cm.).

The weight of these cranes is always less than twice the weight of an ordinary steel crane of equal capacity.

This difference in weight will be decreased in the future by the use of a different kind of steel and the substitution of an artificial stone for the crushed stone and gravel. According to experiments made, during the last few months, in the United States, the concrete made of artificial stone shows, as compared to ordinary concrete, a compressive strength about 25 per cent greater, a bond strength about 20 per cent greater, a resistance to impact about 4 per cent greater and a weight 18 per cent less. The use of this concrete will decrease the weight of the crane from 1/5 to 1/6.

To obtain a proper factor of safety the maximum fiber stress in the concrete of compression members is limited to 498 lb. per sq. in. (35 kilogr. per sq. cm.), even under the most unfavorable conditions. The maximum allowable tensile stress in the reinforcing is 17,000 lb. per sq. in. (12 kilogr. per sq. mm.). This value is taken because it is necessary to use reinforcing with a high resistance to rupture but with a very low elastic limit.



Three-ton Derrick Manufactured by Perbal.

In each member the steel and concrete have been so proportioned that:

(a) In the tension members, the reinforcing alone will be sufficient to resist all tensile stresses developed by the dead and live loads.

(b) In the compression members, the concrete and steel will withstand easily the stresses developed under the most unfavorable conditions of loading, taking into account the supplementary stresses due to bending.

(c) In the bending members, the longitudinal steel alone must be able to resist the sudden stresses and the allowable bond stress must never be exceeded.

In addition, hooks on the ends of the bars, stirrups and hoops have been provided to decrease any tendency of the reinforcing to slip.

It will be interesting to follow this new application of reinforced concrete until this type of traveling crane has proved satisfactory.

English Draftsmen's Union

The association of Engineering and Shipbuilding Draughtsmen of Great Britain, according to the June issue of "The Draughtsman," the organ of the Association, has 10,911 members. The Association has won its first official strike, regarding which the above mentioned Journal has the following to say:

"The will to victory has been conspicuously displayed at Rochdale in the case of the draughtsmen employed by Messrs Holroyds. It is our first organized strike and it is hoped that the demonstration of solidarity given by the Rochdale men will encourage the whole profession and infuse such a spirit into the members as to render resort to this weapon in the future unnecessary, or, at most, of infrequent occurrence. This can only be, however, by the members being prepared at all times to vindicate their rights in drastic fashion. The strong scarcely ever need to fight. The struggle was only won by the splendid solidarity displayed by all the men affected and by the skillful and firm conduct of the case by the local leaders as well as by Headquarters. Although the dispute originated on other grounds, it was emphatically a struggle for more leisure and more money and the draughtsmen won handsomely. The victory will have repercussions in areas far removed from the neighborhood of Rochdale. The Association is in dispute at present with another firm on radically different grounds, although justice is the basis of the claim in both cases. The Association demanded the reinstatement of two members, employed by Barclay, Curle & Co., Glasgow, who were dismissed under conditions which led the Association to charge the firm with victimization. The firm, so far, has declined to admit its willingness to reinstate those men and the Association, by means of the publicity of the vacancy lists and other lawful weapons has sought to restrain its members from taking employment with the firm, which is on the look out for men. Up to the date of writing it had been successful in this object, although some misconception had arisen as to the department with which the Association is in dispute. It has been alleged that it is unjust to penalize one department for the sins of another. But there is no justice between those who go to war. The firm, as our Association, is one and indivisible, and it would be worse than foolish not to strike at our adversary's weakest point. A very gratifying feature of this necessarily prolonged, although very limited in extent, struggle, is the loyalty to their class displayed by many draughtsmen who are not members of the Association. They also will come in and receive fellowship among us."

Last December the Association adopted as a national policy a standard working week of 38 hours. This figure was decided upon because the better class of firms already had granted draughtsmen a 38-hour week. A writer in The Draughtsman estimates that at least 50 firms have reduced their draughtsmen's working time to the above standard He then goes on to say:

"In the opinion of the writer this is really an astounding result. Astounding because such concessions have been made—with one notable exception—as the result of a mere request.

"Surely here we have a clear example of the efficacy of organization. The mere fact that the draughtsmen in the offices concerned have organized and have spoken with one voice—without the employment of any threat—has been sufficient to induce these better-class employers to reduce their hours. But although some success has been obtained many failures, too, have to be recorded. For one pliant employer we have been faced with many obdurate ones for whom a request has about as much significance as has the cry of a child for the moon! In these cases our request for a reduction of hours has been looked upon as mere childishness and of no more importance. Had the Association been possessed of funds wherewith to follow up unsatisfactory replies by suitable action, such replies would undoubtedly have been less frequent. Some employers can only understand the argument of force. No matter how reasonable a request may be, unless backed at least by the threat of more forceful argument, in the American phrase, "It cuts no ice."

"Well, at last the Association is settling down to real work. It has decided that to justify itself, it is imperative that a good banking account be built up. It has raised the subscription from a merely nominal figure to one that can be mentioned in Trade Union circles without bringing a blush to the cheeks of the speaker. It has done this for the express purpose of building a reserve fund with which to back its 'appeals to reason.'

"When this reserve fund has assumed proportions commensurate to the size and completeness of our organization numerically, then will employers begin to respect us, then will the various Employers' Federations hasten to grant that recognition for which at the present time we are as it were, 'Crying in the Wilderness.'

"Moreover, this question of hours is, in the writer's opinion, one particularly suitable for settlement between the Federations and the Association. In other words, seeing that the A. E. S. D. has made the 38 hours week its national goal, it is a question for national settlement, rather than for settlement with individual firms. We have no intention, at present at least, of adopting a national policy on the question of remuneration; wages being probably a matter best dealt with locally and through the Control Scheme when that is finally adopted and put into operation. On the other hand, the hours question at once presents us with a general policy for the whole Association. Here we have our common rallying ground. Here is something tangible, understandable by all, presenting the same phenomena to all, and equally desired by all. Hence I say this is a question for national treatment through the Federations and its treatment will be more or less successful as we are more or less wealthy, as we are more or less organized as an Association.

"But, further, when we have finally achieved our purpose and our standard week of 38 hours is an accomplished fact, are we going to stop at that? I think not!

"There is nothing fixed or final about a 38-hour week It is simply an arbitrary standard, fixed as an expediency suitable to the circumstances of the present—that is all.

"The Trade Union movement has in this matter followed a true instinct during the last three-quarters of a century in seeking a continual shortening of the working week. This policy must be pursued in the future with no lessened persistency. It is no answer to this demand to say, as has always been said in the past, that industry cannot stand it. If industry as at present organized will not permit those engaged in it to have reasonable leisure in which to enjoy the good things of the earth, it must be remodeled on more scientific lines and the waste and inefficiency inherent in the present form eliminated.

"Now just a few words about overtime. The Association's policy in this is, that all time worked over and above the normal week should be paid for, the underlying principle being that overtime should be discouraged. It is in actual fact an extension of the working week, and therefore to the extent that it is worked we are robbed of that leisure which should be devoted to the recreation of body and mind. But besides robbing those working it of their leisure, it tends to the unemployment of others. If the unscrupulous employer can avail himself of it, he will not extend his office as his business grows. It will pay him rather to attempt to get more work out of the same establishment by extending the working week of those already engaged, under the guise of overtime. It is bad for those doing the extra work, and bad for those who are seeking work.

"But there is another aspect of the question that should not be overlooked. It has long been recognized by students of economics that the working of systematic overtime has a baneful effect upon wages. There is a distinct tendency for men earning a low wage to be content with it if they can work sufficient overtime to make up the deficiency.

"Hence the Trade Unions are viewing the question of overtime with more and more disfavour. Their objective is to make it unprofitable from the employer's point of view. They contend, and rightly so, that it should only be allowed in cases of temporary emergency.

"To sum up, then, the A. E. S. D. has adopted the policy of a 38 hours week. In the opinion of the writer this should not be regarded as more than a temporary expedient. The ultimate policy should be the attainment of the maximum amount of leisure. In order to do this, overtime, which has many detrimental effects, is to be discouraged and ultimately not countenanced at all, except in cases of real emergency."

Power from Tidal Waters

From The Engineer, June 13, 1919.

An ingenious scheme for harnessing the tidal waters of two or more rivers to obtain a continuous supply of electrical power has been evolved by Mr. J. Smith of J. Smith & Co., engineers, Glasgow. For this purpose Mr. Smith proposes to construct a dam across each river, and install hydro-electric power plant which would be operated by the flow of water from one side to the other side of the dams. There must also be a definite time relationship between the tides of the rivers. Considering one of the rivers at high tide with the dam gates open, the water would be at the levels A, B in Fig. 1. The dam gates are then closed, and at half tide, three hours later, the water will be at the levels A, C. The water turbines are now started and the flow of water through the turbines is adjusted so that for the next three hours the power plant is driven at constant head, the water finally reaching the levels, D, E. It is then necessary quickly to adjust the water during the turning of the tides to the levels F, E by opening all the sluice gates of the dams. The gates are then closed, and in the next three hours the water will rise on the sea side to level B—Fig. 2. The water turbines can then again be operated at constant head for three hours, while the water rises from the levels B, C to the levels D, E. The dam gates are then opened and water must then pass quickly to the river side of the dam, so that the river is raised to level F, which corresponds to high tide. The operations just described would then be repeated, and it will be seen that the turbines for the one river can be worked at a constant head equal to half the rise and fall of the river for three hours from half tide to low tide, and again from half tide to full tide. Considering now the second river, it is chosen with the tides lagging, or leading the tides of the first river by three hours, so that the idle periods of the plant installed on the first river correspond to the working periods of the plant on the second river. Therefore, by choosing the rivers so that the tidal powers are approximately equal, a continuous supply of power can be obtained, the two sets of generators being connected to one system of high-tension mains and working in parallel during the change-over periods.

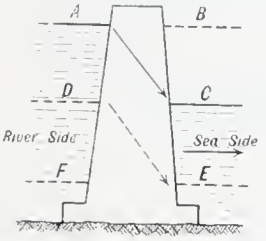


Fig. 1.

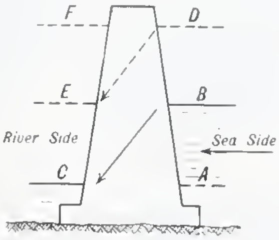


Fig. 2.

As an example of the magnitude of the power involved in these tidal waters, we may cite the figures given for a scheme utilizing the river Severn, the river Dee, the Menai Straits and the river Mersey. The rise and fall of the river Severn at Portishead is taken as 34 ft., and, as explained, only half that fall—17 ft.—is used, the other half making the head which is kept during the whole time the turbines are working. The volume of water used at this head is 74.5 miles in length by one mile broad by 17 ft. deep. The amount of water constantly passing over the fall for three hours averages 187,921,251 cu. ft. per minute, and allowing for the efficiency of the turbine, this corresponds to approximately 4,770,000 HP. Turning to the other rivers, the river Dee, the Menai Straits, and the river Mersey would be grouped together to supply power alternately with the river Severn. In the case of the Dee, North Wales, which has 28 ft. rise and fall, a constant head of 14 ft. is ensured. The volume of water used at this head during the three hours' run—approximately 15 miles long by 4 miles broad by 14 ft. deep—will average 123,099,300 cu. ft. per minute. As regards the Menai Straits, a head of 14 ft. of water is again available, with an average displacement of 47,687,733 cu. ft. per minute. Finally, for the Mersey, where the tide is 26 ft., there is a constant head of 13 ft. of water, and there, it is stated, the water displaced is 99,977,710 cu. ft. per minute, corresponding to an average mileage of 40 miles long by 1 mile broad by 13 ft. deep. Consequently the total power to be obtained from the group will average 5,650,000 HP. The continuous horsepower is therefore 4.77 millions for the river Severn and 5.65 millions for the river Mersey group, but it is suggested that the mean value, 5,210,000 HP., could be maintained continuously by arranging the larger capacity plant to assist the smaller unit. There appears to be a certain flexibility in the system on account of the surplus water available at each end of the working period of the turbines. The Mersey is taken as [illegible] hours 50 minutes behind the Severn at high water and 50 minutes behind the Dee and the Menai Straits.

We understand this scheme has been submitted for consideration to the Water Board Committee of the Board of Trade. Assuming that such large rivers could be employed for this purpose and that the scheme is quite feasible, it is claimed that the average cost per horsepower of plant and cables installed would be somewhat less than £17—about half the figure recently given for the development of the waterways in Scotland—and that the cost of electrical energy would be comparable with that obtaining in countries possessing large hydro-electric installations.

English Architects and Surveyors' Assistants Form Union

From The Surveyor, June 27, 1919.

A well-attended meeting in furtherance of a project for the formation of a professional union for architects' and surveyors' assistants was held on the 13th inst., under the presidency of Major Ernest Gray, M. P., London County Council, who, in introducing the business remarked that, as he understood, the proposed organization was intended for the advancement of the profession to which they belonged, the improvement of the conditions of each individual, and to obtain the power of negotiating in a corporate capacity with the employers. These aims were, he maintained, free from adverse criticism; they commanded his full and hearty support, and he believed they would commend themselves to the public generally, and especially they ought to commend themselves without hesitation to every man in the profession whose interests were not merely personal and selfish, but who desired that the profession to which he belonged should be improved in status by raising the standard of admission and removing defects which existed, thus making the profession more worthy of the trust which the public placed in it.

Speeches were delivered by Mr. E. H. Walker (chairman of the executive committee of the Engineering and Shipbuilding Draughtsmen's Association) and Mr. A. H. Glasspole (member of the executive committee of the Engineering and Shipbuilding Draughtsmen's Association), urging that the association should be made democratic in its structure and methods; that, as far as possible, means should be taken to ensure that the officials should not dictate its policy, but be the servants of the association; that the members should seek to keep the ideal constantly in view, and that by the formation of local branches the association should be placed upon a national basis.

Mr. Maurice Webb (president of the Architectural Association) stated that the council of the association of which he was president looked upon this movement with every possible sympathy, and hoped to continue to allow the committee of the new organization to make use of their premises, and to help it as much as they could as long as it was conducted on the present lines. He appealed to them to make education one of the planks in their platform, and said he thought they should have a proper benefit society, about which there was no possible idea of charity, working in connection with the Approved Society which already existed. Another thing that helped was a really efficient register, while he also thought that the question of "ghosting"—they knew what he meant—was one that should be taken up, because if a man in an office really contributed anything worth contributing to a design it should be recognized.

Captain Evans, a pioneer of the movement and a member of the Provincial Committee, also spoke, and declared that it was up to the assistants to carry on the project by means of enthusiasm. Subscriptions had been received from all parts of the country, and he thought it would be recognized that the union was going to be of great service to provincial as well as London architects and their assistants. Hitherto theirs had been the most lackadaisical of all the professions, but he knew that the heart of the profession was in the movement.

It was stated that the subscription would be 10s. per annum.

New Type of Spillway With Long Crest

From Le Genie Civil, March 10, 1918.

The Société Negri is building, in Italy, in the rich industrial region of Ligurie a group of four hydro-electric plants. These plants will develop about 100,000 kw., which will be distributed in the Roja and Bionia valleys. At present the plant at San Dalmazzo has just been finished. It is located in the upper valley of the Bionia and obtains its water from a storage and regulating reservoir which is one of the most important of its kind in Europe, not only because of the difficulties of constructing the dam, but also because of the originality of its design.

The plant has a maximum capacity of 60,000 metric HP. the head 750 meters, and the height of the dam 58 meters above the foundations. Its altitude is 1,373.50 meters above sea level, which made the construction difficult. This high altitude also subjects the structures to very severe cold and very strong ice pressures.

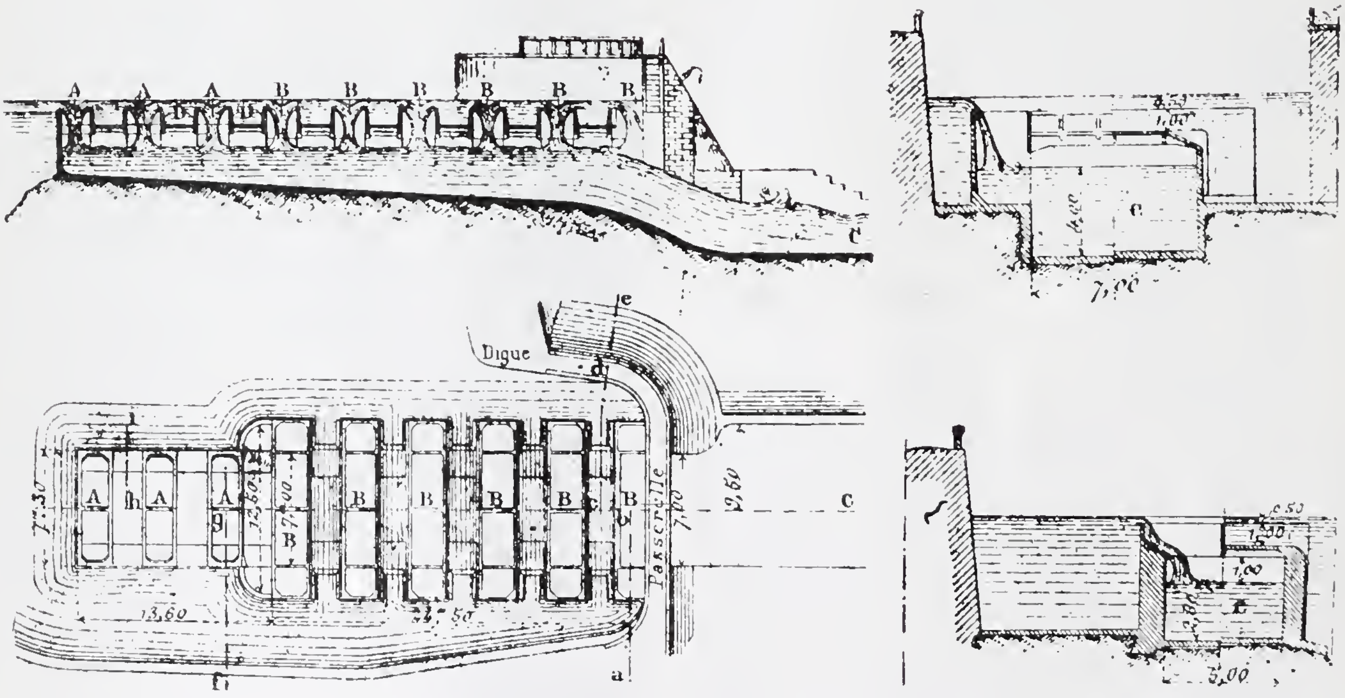
The design and construction of the spillway presented exceptional difficulties because the space in which it had to be built was very narrow, so narrow, in fact, that it was impossible for a straight spillway to handle the maximum discharge of 150 cu. meters per sec.

The Société Negri solved the problem at the San Dalmazzo power plant by adopting a type of multiple crest spillway which M. Luiggi calls a well spillway. Its principal is the multiplication of the weirs over which the water flows by making the spillway deep rather than wide, thus obtaining the required discharge without an excessive head.

Figures 1 and 2 show that the spillway is made up of nine rectangular wells (A, B) of which six (B) have a length 9 meters and the other three (A) a length of (7.5 meters). The dimensions were adopted to make the structure conform as closely as possible to the rock surface on which it is built. Consequently the discharge canal C rests firmly on the rock, and the nine wells through which the water flows are reinforced concrete boxes built over it. All four edges of each box are individual weirs and the required spillway length is obtained by using a sufficient number of boxes. The method of operation is shown in Fig. 1.

Figures 3 and 4 are sections through the spillway and show the method of bracing the boxes with reinforced concrete beams to insure rigidity. The concrete used is composed of 350 kilogr. of cement, 0.40 cu. in. of sand and 0.80 cu. in. of gravel.

This spillway functioned perfectly during the winter of 1917 in spite of ice 19⅝ in. (0.50 m) thick.



Figs. 1-4—Long Crest Spillway at San Delmazzo Power Plant.

Effect of Wheelbarrow Traffic on Road Surfaces at Shanghai

From The Surveyor, May 30, 1919.

In connection with road problems generally in Shanghai, careful consideration was given to the loads carried by wheelbarrows and handcarts with a view of devising means to reduce the obviously injurious effect of the overloading of these vehicles. With regard to wheelbarrows, it was found that 75 per cent had loads of over 700 lb. per inch width of tire, while some had loads of 1,100 lb. per inch width of tire —the wheels in all cases were 3 ft. in diameter. Handcarts of the standard local type, also with wheels approximately 3 ft. in diameter, were found giving loads of 1,100 lb. per inch width of tire. It is not too much to say that 50 per cent of the loaded vehicle cause a greater pressure than any form of macadam road can reasonably be expected to withstand. The wheelbarrow, being a single-wheeled vehicle, causes more damage than the figures show, because the tire is not in full bearing except upon the rare occasions when the vertical axis of the wheel is normal to the road surface. A large percentage of the handcarts are badly constructed and have excessive axle play. Loaded wheelbarrows can be turned without the wheel moving about the axle, and loaded handcarts with a forward movement of one wheel only. As the permissible load per unit width of tire should vary in a certain definite mathematical degree with the diameter of the wheel, a diagram has been prepared showing the loading for all wheels up to 5 ft. in diameter, and the scale of loading has been enforced where special transport permits are required. In view of the excessive loading which has been long permitted, the scale is on a generous basis. While it is fully recognized that any radical and sudden change would act harshly on the owners of existing vehicles, it is important in the interests of road construction and maintenance that reasonable regulations should be enforced.

Studies in the Bacteriology of Water

By DENIS B. WOOD.

From a paper read at the annual summer meeting of the Institution of Water Engineers.

It is well known that bacteriological examinations of water supplies are directed to the detection and enumeration of what are known as "indicator organisms"—that is to say, organisms which are always to be found in large numbers in the excreta of man and animals. The presence of such organisms in water indicates potential danger to the health of consumers for individuals suffering or having suffered, even at some remote time, from typhoid fever and kindred diseases may void the specific organisms in large numbers in their excreta.

Contamination of water with excretal matter derived from animals is of less potential danger, for the lower animals are not to anything like the same extent subject to these diseases. They are known, however, to be subject to infection with the Gäertner group and paratyphoid bacilli, and with animal parasites, though such infections are rare, and contamination with animal excretal matter must be regarded as undesirable. Moreover, as we have as yet no means of distinguishing between contamination with human and animal excretal matter, so similar are their bacterial flora, we are obliged to take a safe course and regard all waters showing definite evidence of excretal contamination as more or less unsatisfactory.

There are three groups of "indicator organisms": (1) The B coli group, (2) the Streptococcus group, and (3) the Enteritidis Sporogenes group. The average numbers in which they are present in one gramme of human faeces are:

B. coli.	Streptococci.	Spores of B. Enteritidis Sporogenes.
100-1,000 million.	100-1,000 million.	1-10 million.

It is evident, therefore, that tests based on the enumeration of B. coli and streptococci will be the most sensitive. In this paper only these two groups will be considered.

The B. Coli Group.—Members of the B. coli group have one characteristic in common—viz., the fermentation of lactose with production of acid and gas. The study of this group reveals the fact that it can be divided and subdivided into a number of types.

From MacConkey's results it appears that 87 per cent of the lactose-fermenting organisms present in human faeces all produce indole, acid and clot in milk, do not liquefy gelatine nor give the Voges and Proskauer reaction. In other words, they possess, practically speaking, the cultural characters of Houston's "typical B. coli." Houston found that about 85 per cent of the lactose fermenters present in human faeces, and 65 to 85 per cent of those present in sewage, possessed these characteristics. The results of his investigations on the viability of members of the B. coli group in soil and water show that the atypical varieties persist for longer periods than the typical, and are therefore less characteristic of recent contamination. Houston's definition of typical B. coli is admirably suited to routine bacteriological examination, and has been very generally adopted as a basis for bacteriological reports.

The Streptococcus Group.—It sometimes happens that in a water examination only lactose fermenters having the characteristics of Houston's "typical B. coli" are to be found. It is then a great advantage to have recourse to another test, and the most satisfactory corroborative test is based on the enumeration of streptococci. Savage and Read have shown that the majority of waters showing evidence of contamination on the B. coli basis contain streptococci.

In calculating percentages nothing is to be gained by working out the percentage of water-samples which contain streptococci or B. coli respectively in the different amounts. The percentage results are worked out in two ways. In one way each group of B. coli prevalence is taken separately and the percentage prevalence of each group of waters on a streptococcus basis is calculated. In the other way each group, of streptococci prevalence, is taken separately, and the percentage prevalence of the waters on a B. coli basis is recorded.

An example will make this clear. Take, for instance, 118 samples from deep-water supplies containing B. coli in 10 or 30 cm.; 58 or 49.2 per cent contained no streptococci. Or take the 198 samples from deep-water supplies containing no streptococci, 61 or 32.3 per cent contained B coli. The mean of these two numbers (49.2 and 32.3) is 40 per cent, and gives a fair average of the number of samples in which B. coli may be present in only moderate numbers and streptococci absent. In other words, the chances are rather more than even that streptococci will be found, and if not found in one sample they probably will be in the next, or at any rate in subsequent examinations. This correlation between B. coli and streptococci is a point the author particularly wishes to emphasize. Apparently the value of this test as carried out by Savage has not been fully appreciated.

The streptococcus group can also be differentiated into a variety of types by fermentation reactions; those producing acid in lactose are particularly typical of excretal contamination. Differentiation of this group, however, is seldom practiced.

The streptococcus enumeration is particularly valuable as an index of recent contamination. This was shown by the results of an investigation carried out by the present author in conjunction with Dr. W. G. Savage on the relative viability of B. coli and streptococci in water under conditions closely resembling those of a well. In this investigation an earthenware pipe cemented at the bottom and holding about 40 litres of water was used as the model well. The water was contaminated with excretal matter emulsified with water, or with sewage, and examinations were made at regular intervals to ascertain how rapidly the organisms diminished in numbers and finally disappeared

These experiments with excreta or sewage added to a large bulk of water yield minor differences in the individual experiments, but in general they show a rapid diminution and elimination of the streptococci and a continuous, yet not quite so rapid, diminution in the number of B. coli. With the latter it was more common to find persistence in small numbers for a period extending to many weeks. The elimination of the streptococci was particularly uniform and rapid. At the end of three weeks in only two experiments were they present in more than insignificant numbers.

The decline curves of both organisms agree very closely, as can be seen most readily if the figures are plotted out as graphs.

Comparison with the viability of the typhoid bacillus is of special interest. Sir A. C. Houston's investigations in the viability of uncultivated typhoid bacilli in river water showed that they died out within three weeks, even when as many as 38,000 were present per c.c. of the infected water.

Several lactose-fermenting organisms isolated from various sources gave the Voges and Proskauer reaction, very few of which—only 6.3 per cent—were represented in human faeces. These types have recently attracted the attention of American bacteriologists, and have been shown by them to be rare in the excreta of man and animals, more common in sewage and surface water, and the predominant types in soil and grains. They can be distinguished in the laboratory by two tests—(1) the methyl-red test, and (2) the Voges-Proskauer reaction, alluded to above. These two tests are very closely correlated, and by them the lactose-fermenting organisms can be divided into two main types, which are known as—

(1) The methyl-red positive type ("M.R.+"), or the Voges-Proskauer negative type ("V.P.—"), and

(2) The methyl-red negative type ("M.R.—"), or the Voges-Proskauer positive type ("V.P.+").

The first is characteristic of excretal contamination and is sometimes called the "Coli type," while the second is not characteristic, at any rate, of recent excretal contamination, and is sometimes called the "Aërogenes type," after its type organism, B. lactis aërogenes.

These tests commend themselves to the bacteriologist as suitable for routine work in the same way as the tests of Houston, by their simplicity, and are particularly to be welcomed by those in whose experience particular water supplies have yielded only atypical varieties of lactose fermenters according to Houston's definition.

Results show how small a proportion of the lactose-fermenters of excreta belong to the "M.R. " type and how large a proportion are present in soil and grains. Occasionally a specimen of faeces contains a fairly large proportion, the high figure of 26 per cent obtained by Rogers, Clark and Lubs was due to a single abnormal specimen, and to the employment of a method specially selected to favor the growth of this type, and does not represent the average numbers in which they were actually present.

Records of various observers strongly suggest that organisms of the "M.R.—" type are the more resistant, the more capable of surviving outside the animal body, and of finding a favorable environment in soil.

Winslow and Cohen carried out experiments on the relative viability of these two main types in water, and their results show that there is distinct evidence that the viability of the "M.R.—" type is greater than that of the "M.R.+" type.

Experiments show a decrease in the "M.R.+" type from 50 to 5 per cent, and from 56 to 0 per cent respectively (in sixty days). On the average, however, the reduction in the percentage was from 54 to 29.

As the methods employed by American bacteriologists differ in some respects from those usually employed in this country, it was thought advisable to investigate how frequently organisms of the "M.R.—" type were likely to be encountered in the routine examination of waters by English methods, and, by noting the association or absence of association with streptococci, to ascertain whether the presence of lactose-fermenting organisms of this type affords evidence of recent excretal contamination or not.

Observations were therefore made by the author of a large number of samples of water from various sources. Out of 200 samples in which lactose fermenters were present, organisms of the "M.R.—" type were encountered in 66, or 33 per cent.

Lactose fermenters of the "M.R.+" type and streptococci were absent from practically every sample, strongly suggesting that in general no recent excretal contamination had occurred, for if it had streptococci would have been found in about 50 per cent of these samples. (These samples were of water of good repute.)

Other samples from shallow wells, etc., were as follows:

(1) Those containing no streptococci and no lactose fermenters of the "M.R+" type, suggesting no recent contamination.

(2) Those containing streptococci and probably lactose fermenters of the "M.R.+" type also, though, since contamination was sufficiently proven, further search for this type was not made.

(3) Those containing streptococci and lactose fermenters of the "M.R.+" type, further search having been made for this type for the purpose of this investigation.

It may be asked, How is it that the "M.R—" type are found in samples of groups 2 and 3 in which recent excretal contamination is proved? The explanation obviously is that a certain amount of self-purification has already taken place, but the contamination is sufficiently recent for organisms of the "M.R.+" type and streptococci to be present also in larger quantities of the sample.

Of special interest was the occurrence of lactose fermenters of the "M.R—" type in the deep wells, several miles apart, supply consists of seven or eight wells, several miles apart, varying in depth from 250-450 ft. These wells yield a very pure supply, lactose-fermenting organisms being absent from 100 c.c in 85 per cent of all samples examined. In the spring of 1918 lactose fermenters were found in a much larger proportion, and all (with one exception) were found to belong to the "M.R.—" type. Streptococci were invariably absent. The inference is that the most resistant types only of the lactose fermenters reached the underground water, though why they were present in obnormal numbers at this particular time could not be discovered. The only exceptionally heavy rainfall occurred five months previously.

The large majority of lactose fermenters of the "M.R.—" type (about 85 per cent) show capsule formation. Experiments by the present author show that some capsulated organisms display remarkable viability in boiled (or steamed) hard water. In one experiment the organism added to such water, containing no measurable trace of saline or organic ammonia, was isolated after a period of three and a half years. It should be noted that it is only in boiled (or steamed) hard water that such remarkable viability is observed, though in unboiled water some of the capsulated types live longer than the non-capsulated (in one experiment fourteen weeks as compared with seven weeks). The phenomenon seems to be dependent upon the slow deposition of supersaturated carbonate of calcium or hydrate of magnesium, which takes place in the boiled water after filtration. Whether the necessary conditions for prolonging viability occur in limestone silt is a matter worthy of investigation.

Other experiments confirming this remarkable behavior, one of which was carried out independently by Dr. W. G. Savage, are recorded in the Journal of Hygiene Vol. XVI., No. 3, January, 1918. In periods varying from five to eleven weeks, multiplication from fifty to one hundred fold was recorded.

Both strain T. and strain N.D. gave the Voges-Proskauer reaction, and belong to the "M.R.—" type. Strain N.D. produced indole and acid and clot in milk, and was therefore indistinguishable from Houston's "typical B. coli," except by the methyl-red and Voges-Proskauer tests.

Conclusions.—(1) Although attempts to distinguish between human and animal excretal matter by the characters of lactose-fermenting bacilli present have so far been unsuccessful, some measure of success has attended attempts to distinguish between recent and less recent contamination by the identification of the less resistant and more resistant types.

(2) Clemesha based his differentiation on MacConkey's classification; Houston on the more simple indole test; Savage retains the milk-clot test, and notes marked weakness of lactose fermentation, having shown that these attributes tend to diminish with soil environment. American investigators have recently based their differentiation on the methyl-red and Voges-Proskauer tests.

(3) The more resistant the types, obviously, the less evidence there is of recent contamination in waters in which they are found.

(4) Most valuable information as to recency of contamination is afforded by the enumeration of streptococci by the simple method of Savage.

(5) Association or absence of association of lactose fermenters with streptococci can therefore be used as a control in judging the merits or demerits of any of the above methods of differentiation.

(6) Relative absence of association of the lactose fermenters of the "M.R.—" type with streptococci strongly supports the view that they are the more resistant types.

(7) Experiments show that, under certain conditions, the viability of capsulated organisms of the "M.R.—" type may be very considerable. Whether similar conditions occur in Nature is a matter requiring further investigation.

Precautions in Using Wood Inserts in Wet Concrete

In a recent issue of The Carpenter and Builder, of London, a correspondent calls attention to the necessity of exercising special care in the insertion of wood in wet concrete for the purpose of fixing-blocks, etc., for securing fittings, and various other requirements. He states that such a method is outside the bounds of practicability on account of the expansion due to moisture absorbed by the woodwork from the wet concrete, the effect of which is invariably to cause serious fractures to occur in the concrete. The writer has in mind an important public work where it was necessary to make holes in the top of a concrete wall to receive later some cast iron standards. Upon inspection he found that square wood boxmoulds made of one-inch board had been inserted in the wet concrete for the purpose of forming the necessary standard holes. In every case the moulds had expanded to such an extent as to have considerably damaged the stability of the concrete by fracture where strength was most essential. This led the writer to make investigation and experiments, which led to rather interesting results. Two wooden fixing blocks were made; one was painted with two heavy coats of paint with a view to making it impervious to moisture; the other was thoroughly soaked in water with the idea of causing the expansion to be complete before placing it in the concrete. Each block was then placed in two equal sized blocks of concrete in moulds and allowed to set and dry. Very soon, however, results were apparent. The painted wood block had, in spite of the paint, swollen and caused very bad cracks to appear in the concrete, while the other wood block that has been impregnated with the water before going into the wet concrete showed no signs of fracture whatever to the concrete. The shrinkage when dry was immaterial, and made no detriment to the holding propensity of the block, which, by the way, was dovetailed in form."

Ritchie Pre-Cast Unit System of Concrete Shipbuilding

By W. NOBLE TWELVETREES,

From Engineering, June 27, 1919.

In most of the British yards established for the building of reinforced concrete ships and barges, the monolithic system of construction is predominant, the idea being to follow closely the methods successfully applied in the forms of buildings, reservoirs, bunkers and other land structures. In some cases pre-cast parts or units, such as transverse frames or hull plates, have been incorporated with monolithic work, a method of procedure which is often convenient in land structures, as for instance, railway or highway bridges which have to be built or rebuilt in a minimum period of time with the object of intefering as little as possible with traffic. The method has also proved useful in the case of wharves and jetties in tidal waters, as a means of overcoming the difficulty of executing concrete work between high and low-water levels, or even below the latter.

Two or three shipbuilding firms have gone a step further by adopting pre-cast units on a more extensive scale. Thus, in the Waller system, the skin of the hull is formed entirely of pre-cast units erected and combined with monolithic transverse frames and longitudinal members. In the Stroyer system adopted at Tilbury, pre-cast units of very large dimensions are employed in forming the parallel portion of the hull, the transverse frames and curved ends being moulded in the usual manner. A third method to which the present article is devoted consists in the use of pre-cast units of relatively small size for the construction of the entire hull, the units being carefully jointed together after erection and braced by the addition of stringers, keelsons and other members moulded in situ.

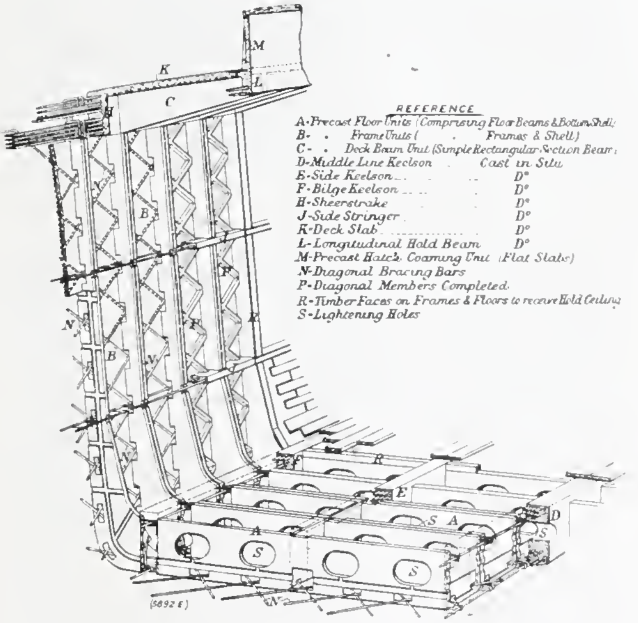

REFERENCE
A-Precast Floor Units (Comprising Floor Beams & Bottom Shell)
B- . Frame Units (. Frames & Shell)
C- . Deck Beam Unit (Simple Rectangular Section Beam)
D-Middle Line Keelson . Cast in Situ
E-Side Keelson . D°
F-Bilge Keelson . D°
H-Sheerstrake . D°
J-Side Stringer . D°
K-Deck Slab . D°
L-Longitudinal Hold Beam D°
M-Precast Hatch Coaming Unit (Flat Slabs)
N-Diagonal Bracing Bars
P-Diagonal Members Completed.
R-Timber Faces on Frames & Floors to receive Hold Ceiling
S-Lightening Holes
M
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Fig. 1—Ritchie System of Concrete Ship Construction.

The system now in question is that originated by Mr. Harry C. Ritchie, A. M. Inst. C. E., A. M. I. N. A., of Liverpool, and adopted so far by Concrete Seacraft, Limited, Fiddlers Ferry, Lancashire; Messrs. Hughes and Stirling, Preston Dock; Stuart's Concrete Ship Company Limited, Northfleet; and Blackett's Concrete Ships, Limited, Stockton-on-Tees. The writer is informed that arrangements are now in progress for the employment of the system in Italy, Scandinavia and India.

In the development of his unit system, Mr. Ritchie had in view two important ends: (1) To reduce to an absolute minimum the amount of timber supports and forming required on the building berth; and (2) the arrangement and spacing of frame members in a manner similar to that generally specified for steel ships and a reduction in scantlings with consequent reduction of structural weight.

To assist in making clear the essential features of the system, a diagram, Fig. 1, is annexed, showing the units adopted by Mr. Ritchie and the means adopted for jointing and bracing them after erection. The hull is built up of units each consisting of a thin plate and two deep flanges. Therefore the complete unit has a troughlike cross-section, but the depth of the flanges is varied suitably with the position of the units in the hull of the vessel. Referring to Fig 1, the two rows of units for the bottom have flanges of uniform depth which may be left solid or pierced by oval openings as in the diagram. Rectangular openings are formed in the flanges just above the upper surface of the plate to provide for the passage of diagonal bars which are afterwards concreted so as to constitute bracing members.

When the bottom units have been placed in position, the abutting flanges are cemented together so that each jointed pair of flanges forms part of a transverse frame. The units for the sides of the hull are similarly formed and jointed together. Each bottom unit extends from the bilge to the middle line athwartship, so that two units make up the full span of the bottom. The side units extend from the bilge to the sheer strake, and above them are the deck beam units of rectangular section, not comprising any portion of the deck slab, which is moulded in situ. All the longitudinal members are moulded in situ about the units after the latter have been assembled. In positions where the longitudinals are required to connect the ends of units, as at the centre line and bilges, the main reinforcement of the units projects in hooked form, the loops from adjacent units being concentric so that they can be connected securely by means of steel pins and wedges. The other longitudinal members are formed by passing the main reinforcing bars through the openings left in the bottom and side units, and by concreting in moulds after the auxiliary reinforcement has been assembled.

An important feature of the Ritchie system is the provision of diagonal bracing as shown in the diagram. The reinforcing bars for the diagonals are close to the inner surface of the shell plates and pass through the openings left for the purpose in the flanges of the units. The bars are anchored to the shell by means of U-shaped stirrups, the ends of which project from the pre-cast units along predetermined lines. The diagonals are completed by concrete moulded in situ.

One of the advantages of constructing ships of relatively small pre-cast units is to be found in the fact that the units can be made with the shell face upwards. Thus, what is destined to form the outer surface of the hull can be trowelled perfectly smooth, thereby reducing skin friction to a minimum, and at the same time providing a good and pleasing exterior surface.

The vessels built at yards where the Ritchie system has been adopted, are with one exception dumb barges of 1,000 tons deadweight capacity in general accordance with the specification and drawings of the Ministry of Shipping.

New Concrete Water Towers in Germany

Several concrete water towers were built in Germany during the war, according to the Journal für Gasbeleuchtung of April 5, 1919, which gives details of some of these structures. A water and outlook tower was erected in the town of Schildberg, in Posen, from a design of Klein and Wolff, architects at Breslau. A tank of 250 cu. metres capacity free, i. e., without connection with the sustaining structure, rests on a floor of reinforced concrete borne by eight pillars of reinforced concrete joined by thin ornamental walls. The winding stairs are of moulded blocks made to represent stone. At the top cornice level is a circular outlook gallery. The cost of the tower was Mk. 70,000. Another structure is a water-tower or industrial works in Upper Silesia. The tank, which has a capacity of 2,000 cu. metres, is 31 metres above the ground level. Below this tank is another of 150 metres capacity for drinking water. And on the ground level is yet another of the same capacity for ozonising purposes. Difficulties with the foundations made it necessary to excavate down to the firm rock, and to fill the excavation with 1 to 12 concrete. Here again the main tank is independent of the supporting structure. It is constructed of an inner portion of strong cement 4 centimetres thick. It is carried on concrete pillars bound together at intervals. The total cost of this structure was Mk. 200,000.

Experiments with Clay in Its Relation to Piles

By ALFRED S. E. ACKERMANN.

From The Surveyor, March 14, 1919.

This paper records the results of 95 experiments, some taking 40 hours each, made with clay during the period December, 1917, to February, 1919. The original object was to determine the relationship between the horizontal pressure and the depth at any given point in clay, the method and its theory having been devised about a year before December, 1917.

The clay used for the experiments was obtained from the back garden of the author's house at Hempstead Garden Suburb, London, at a depth of about 2 ft. from the surface. It is yellow in color, and after being puddled in the hole from which it was obtained it was taken into the workshop in the house where all the experiments were made. It was then further puddled by being squeezed bit by bit through the fingers, all stones that were noticed being removed, and the portions so treated were put in a vertical coal-scuttle until it was full. The clay in the scuttle was puddled from time to time so as to make it as homogeneous as possible.

By having only one guide hole for the guide and load rod in the apparatus used there was no danger of cross-binding. The load was applied to the top of the rod by placing weights in the self-centering carrier, which ensured the load acting centrally and vertically down the rod, for the self-centering carrier and the rounded top of the rod constitute a rude form of ball-and-socket joint. Care was taken to keep the guide rod vertical throughout each experiment. This needed little more care than that necessary to start with it vertical.

The penetration h was obtained from two measurements on two opposite sides of the pile or other body which was being gradually forced into the clay (for in all the experiments the loads were applied gradually. No impactive forces were used such as are used in pile-driving). Each of these two measurements was made by callipers vertically between a horizontal projection from the top of the pyramid (or from a bracket on the guide-rod) and a small plank of wood which before the start was pressed into the clay until the top surface of the wood was level with the surface of the clay. The mean of these two readings was deducted from the initial reading, when there was no penetration, the difference being the penetration h.

It was found in the case of the pyramids that they soon came to rest, especially with the larger percentages of water, but in the case of the bodies being parallel, or nearly parallel, sides there was a tendency for the penetration to increase very slowly for a considerable time, but ultimately these bodies, too, came to rest. In consequence of this creeping, each load in most of the experiments was left on for the same time, so that the readings of h might be comparable, even though a somewhat greater value of h would probably have been obtained if the loads had been left on longer.

In the earlier experiments it was not realized how extremely important is the effect on the results of the percentage of water in the clay, and this percentage was consequently determined only in a few of the earlier experiments. One of the most important facts brought out by the experiments is this effect of the water in the clay, and when once this had been appreciated the percentage was always determined for each set of experiments.

The total vertical supporting capacity of piles with parallel or cylindrical sides is made up of two or three factors: the friction and/or cohesion on the vertical sides, and the vertical pressure on the end or point. The separation of these factors does not seem to have been done. Taking into account the great length of a pile compared with its cross-section, it would appear that the frictional resistance is by far the more important factor, but at least one experimenter (Crosthwaite: Proc. Inst. Civil Engineers, Vol. CCIII., p. 187 to p. 207, Dec. 19, 1916), has stated that in his experiments with a model cylindrical pile with a flat end "friction did not come in," and that this was due to the action of the clay in squeezing out horizontally from beneath the flat end of the pile, whereby a small annulus was formed between the clay and the vertical cylindrical surface of the pile. The experiments herein recorded show that there is considerable friction and/or adhesion between the vertical surface of the pile and the clay.

Two or three of those who took part in the discussion of the papers on clay by A. L. Bell (Proc. Inst. Civil Engineers, Vol. CXCIX, 1915, pp. 233-336) and P. M. Crosthwaite (Proc. Inst. Civil Engineers, Vol. CCIII., 1917, pp. 124-210) expressed their belief that moist clay probably acted as a heavy viscous fluid, but no proof of this was offered. With a view to discover the facts experiments were made with duralumin discs 63, 37 and 26 mm., respectively, in diameter and only 1 mm. thick. Owing to the thinness of the discs and their polished edges, the friction of the clay on these edges has been neglected, though an approximate correction for this could be made if necessary. The experiments were most convincing. At certain critical loads the discs started and continued without additional load to sink comparatively rapidly into the clay, and the motion continued until stopped by the action of the bottom of the bucket or the weights touching the guide frame.

In all cases the water in the clay was 29 per cent, and in all three cases the pressure of fluidity had been reached when the penetration was about 100 mm. It was pretty obvious that if there were a pressure of fluidity it would be independent of the diameter of the disc used to determine it; but the assumption that for the same penetration and percentage of water the mean friction on the parallel sides of piles of different diameters would be the same also seemed obvious. The author, having proved himself wrong in this apparently reasonable assumption, was gratified to find that at least the pressure of fluidity was independent of the diameter, for this enabled an allowance to be made for the pressure on the ends of piles of different diameters and the same penetration, and deducting these from the total loads the total friction on the vertical sides of the piles was obtained, and hence the mean friction per unit of vertical surface.

Crosthwaite, in his paper (Proc. Inst. C. E., Dec. 19, 1916) refers (p. 149) to the fact that the penetration of a cylindrical pile, "instead of varying directely as the pressure, increases enormously with the pressure," and he states, p. 160: "The behavior of clay under increasing pressure is to the author a complete mystery, and he can offer no physical explanation as to why the settlement should vary as the square of the pressure." The explanation was not given in the long discussion and correspondence on that paper. The author of this paper claims that his experiments provide the explanation—namely, that increased penetration was due chiefly to the pressure of fluidity having been reached, and possibly also to the pile having "rubbed itself free" in the upper portion that had penetrated.

In the discussion on Bell's paper (Proc. Inst. C. E., Jan. 12, 1915) Mr. J. Mitchell Moncrief said (p. 278): "He would be obliged to anyone who would explain to him why the average frictional resistance was less at 47½ ft., 62 ft., and 65 ft., than at 22 ft., 20 ft. and 21 ft." The author of this paper suggests that his experiments afford the explanation of this also—namely, that it was due to the reduced friction on the upper portions of the cylinders when they had sunk into the greater depths, owing to these upper portions, "rubbing themselves free." This explanation was given by Mr. Bell at p. 333 in his reply to the discussion on his paper.

The following conclusions relating to clay appear to be justified (and propably others may be) by the qualitative and quantitative results of the experiments:

1. For the tapered bodies gradually forced into clay the load necessary to produce a given penetration is proportional to the area of the surface of contact between the clay and the body.

2. The load to produce a given penetration is very much greater the less the percentage of water in the clay.

3. Clay containing a definite percentage of water, and at a definite temperature, has a definite pressure of fluidity, and when this pressure is reached and maintained the clay yields indefinitely as a dense viscous fluid, unless it be restrained from flowing or caused to rise so as to produce a statical head of clay.

4. The pressure of fluidity is greater when the percentage of water is less, or when the temperature is lower.

5. The pressure of fluidity per se is independent of the depth and depends solely on the percentage of water in the clay and the temperature of the clay.

6. For equal depths, tapered piles support a larger load per unit volume of the piles than piles having parallel sides.

7. The reason for (6) is that in the case of tapered piles

their surfaces keep in more intimate contact with the clay, with the result that the support due to the friction on their sides is greater than is the case in parallel piles.

8. With a view to increase the resistance of piles they should be corrugated as well as tapered.

9. The reasons why parallel piles with blunt ends are not so efficient per unit volume is that the pile in entering the clay rubs the surfaces near the top of the hole made so much that the friction (or cohesion) is reduced there, and also because the clay in squeezing laterally from under the end partially loses contact with the sides of the pile, thus also reducing the friction on which the supporting capacity of a pile depends.

10. The mean intensity of friction for the same depth of penetration on the sides of parallel piles is greater in the case of piles of small cross section than in the case of larger ones; but if the diameter of the pile be reduced beyond a certain amount (the depth of penetration being constant) then the mean intensity of the friction appears to decrease again Consequently for a given quantity of material of which to make piles a large number of small piles is more efficient than a smaller number of large ones.

11. Pointed piles are more efficient per unit volumes of pile than blunt ones because the points cause a more gradual lateral displacement of the clay, thus leaving it in more intimate contact with the sides of the pile.

12. The action of the point of a pile is to cause the pressure of fluidity to be attained on its surface, whereupon the clay flows out of the way.

13. The resistance to penetration is considerably greater the lower the temperature of the clay, probably because the pressure of the fluidity increases as the temperature decreases.

14. The density of clay decreases as the percentage of water increases.

15. The work done per unit volume of displacement increases as the angle of taper decreases; but when the taper approaches 0, or is 0, then the work done is less than when the angle of taper is larger, for the reasons given in (9).

16. When forcing a disc into clay, the sides of the hole do not crush in (unless a certain critical depth be attained) because the pressure of fluidity of the clay having been attained immediately under the disc, the clay flows laterally; but the moment it has escaped from beneath the disc the pressure is reduced to the statical pressure corresponding to the local head of clay, and when this is less than the pressure of fluidity the clay does not flow into the hole made by the disc, but, if the penetration of the disc be carried far enough, then ultimately the statical head of clay will be equal to the pressure of fluidity and the sides of the hole near the bottom will crush in.

17. The friction of clay on wood is greater than on tin plate.

18. The tensile strength of the clay experimented with was greater when it was raw and dry than when it was baked.

19. Clay is elastic.

20. The contraction of clay on drying probably increases as the percentage of water in the clay increases.

Recovery of Phosphates and Ammonia from Sewage.—The obtaining of fertilizer phosphates from sewage is suggested in the Chemiker Zeitung (Jan. 21, 1919) by J. Gonni, of Berlin. He gives no data as to the probable yield and admits that the sewage treatment for phosphates alone would be unprofitable; but he claims to gain the ammonia at the same time and further to disinfect the sewage and to utilize the residue —familiar claims of workers on the sewage problem. He also points out that where ammonia is recovered from gas water his process might be worked in similar apparatus. The main idea of his suggestion is that phosphoric acid is precipitated as calcium phosphate from solution of calcium chloride and other calcium salts by sodium phosphate when ammonia is present. He separates the liquid from the solid sewage in special apparatus which prevent the escape of ammonia and also prevent explosion of any explosive gas mixtures. The clarification is facilitated by adding certain refuse or by-products of the process to the sewage. Calcium salts, also from the refuse, and some sodium phosphate, if necessary, are then added to the liquor, and the mud precipitated is filter-pressed or centrifuged. The settled liquid passes into distilling apparatus; more mud is obtained, and the precipitation and distillation are repeated.

New Method of Rebuilding Masonry Bridges

By MM. LUTTON,

From Le Génie Civil, Jan. 1, 1919

Many railroad bridges in the north and east of France, which were destroyed during the war, will soon have to be rebuilt. The rebuilding of the metal bridges will not be especially difficult for the factories will shortly be able to furnish the necessary materials. But this is not the case with masonry arch bridges. The materials for these, such as cut stone or ashlar are not available because the operation of many of the quarries have been suspended and because good stone masons are very scarce. Another difficulty is found in the wooden centering for the arch during construction. This centering is not easy to build and requires skilled workmen and large quantities of timber. In many cases the presence of the debris from the old bridge in the stream makes it almost impossible to secure firm foundations for this centering.

These different reasons have led to the use of concrete arches because sand and gravel can be easily obtained and to the development of construction methods which will avoid the use of wooden centers.

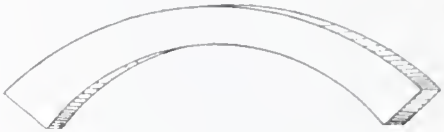


Fig. 1—Sketch of Ring.

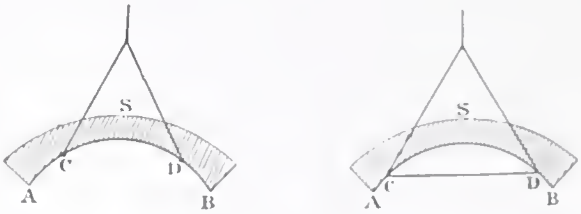
The Compagnie de l'Est has solved the problem by using reinforcing which is strong enough to support the forms and concrete during construction.

Another solution consists in building up the arch to the required size with thin, pre-cast arch-rings placed side by side. The breadth of each of these rings is so determined that it is possible to lift, transport, and place the ring with the aid of the railroad cranes. The breadth, therefore, varies with the span.

For example, a bridge for a double track, 26.5 ft. (8 meters) wide and 26.5 ft. (8 meters) span, whose arch has a mean thickness of 3.3 ft. (1 meter) would be built by placing twenty of these arch rings side by side, each ring being about 16 in. (0.4 meter) in breadth. The weight of each ring would be about 44,000 lb. (20,000 kilogr.), which can be easily handled by the railroad cranes.

The question of lifting, transporting and placing the rings without subjecting it to undue stresses and deformations is most important. This is accomplished by the use of light reinforcing, by locating the points of suspension carefully and by providing the rods if necessary.

Figures 2 and 3 show diagramatically how it is possible to support the ring. In Fig. 2 the ring AB is suspended from two points, C. and D, located a certain distance from the end. The parts AC and BD act as cantilevers and should be reinforced lightly on the extrados. The middle part, CD, acts under its own weight, as a beam resting on two supports, and develops a tendency to crack on the intrados at the point S, and to spread the supports C and D. But the bending moments developed at C and D by the cantilevers counterbalances this, and in turn tends to crack the arch on the extrados at S and to bring the points C and D nearer together It can be seen, therefore, that it is possible to so locate C and D that the stresses in the middle part of the ring will not exceed a specified limit.



Figs. 2 and 3—Method of Suspending Ring.

In Fig. 3 the arch AB is suspended from points C and D near the ends, and it is consequently necessary to add the tierod CD to keep them from spreading and cracking the arch.

The suspension cables are fastened to short pieces of rail passing under the arch at the selected points and resting against reinforced projections cast on the ring.

While being transported, the ring rests on the pieces of rail which in turn rest on supports built on the car.

The rings are cast and, to raise them to a vertical position a frame of rails is used. This is slid under the ring and bolted together; the short pieces of rail to support the ring are fastened to this frame and the whole is then turned to a vertical position with a crane.

The rings are cast, either near the bridge to be rebuilt, if the ground permits, or at the nearest station where materials can be easily obtained and are carried to the job on cars. Since the rings are cast flat, only simple wooden forms, easily built, are required. The rings may be made as rapidly as desired, depending upon the number of workmen. While this goes on and while the rings are drying, new supports on piles or the abutments of the old bridge are prepared to receive them.

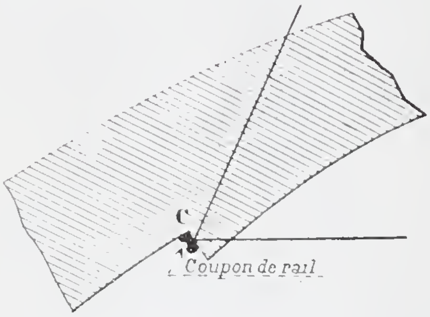


Fig. 4—Position of Supporting Rail.

When the arch rings arrive on the job they are lifted up by means of a crane or cable way and lowered on to the abutments. Before removing the suspension cables a wedge is driven into the joint between the ring and support and concrete poured around it as soon as the cable is out of the way. These wedges are made of concrete and are left in the joint.

After all rings are in place, transverse tie rods are put in to hold them firmly together. The vertical cracks between the rings is then filled with cement mortar and a layer of concrete is placed over the whole arch. Then the spandrels are poured and finally the space between the spandrels is filled and brought up to grade.

Diving Bell for Quay Wall Construction at Gothenburg

The Teknisk Tidskrift of April 16, 1919, contains an interesting description of the bell used for the Central Harbor at Gothenburg. The bell consists of an airtight chamber, 32 ft 10 in. long by 24 ft. 8 in. wide, suspended from an overhead traveling crane with longitudinal and transverse travel. It is supported from rails resting on piles driven along the quay wall and securely held in position by diagonal struts, as cross ties would have interfered with the working of the bell. It is provided with two air-locks, one for workmen, and the other for materials, the air chamber is 11 ft. 6 in. high, arranged for water ballast tanks on top. To sink the bell, water is pumped in by a 4 in. electrically driven centrifugal pump. The maximum air pressure used is 21.2 lb. per sq. in. above atmosphere equivalent to 50 ft. of water. The quantity of water in the tanks is regulated by the air pressure through a special valve which permits surplus water to overflow and adjusts the total weight of the diving bell to the depth of immersion. Compressed air is supplied by a blowing engine erected on the top of the diving bell and driven by a 6 Hp. electric motor. It is capable of delivering 350 cu. ft. of free air per minute at a pressure of 21.5 lb. per sq. in. The lower edge of the diving bell can be raised 5 ft. above water level in order to be quite clear of the quay wall which is a shell of reinforced concrete with a heavy top and suitable partition walls. It is constructed in sections of 164 ft., which are completed in two weeks, the wooden forms being fixed the first week, and the concrete cast the second week. The whole of the work is executed under compressed air, the diving bell being raised as the work proceeds vtically.

The Sense of Art in Engineering

From The Engineer, April 25 and May 9, 1919.

It has been said that an intensified period of art influence invariably follows a great period of warfare, and as it is certain that a great period of engineering activity will, sooner or later, follow after peace is declared, it may not be waste of time to consider the possible relations of art and engineering, after the present insane Germanic influence has been put under proper control.

As Mr. Waddell says in his "Bridge Engineering," the foundation of æsthetics is of the subjective order, being the quality of the impression made on the mind of the observer by the thing observed. The condition of mental development of the observer has everything to do with the effect, pleasing or otherwise, produced by the object, as witness the different and varying conceptions of the beautiful held by the various divisions of the human species during the successive stages of their evolution.

The precepts of art are not by any means absolute and immutable; the problem of embodying them in engineering works is not an easy one, and cannot be solved by theory alone. We do know, however, that the present and newest types of straight girder and cantilever bridges are in many cases an offense to the landscape, and that the vast but old aqueducts of the Romans, the pleasing arch bridges of stone, the catenary curves of suspension bridges, are, or are fast becoming, obsolete. We also know that the earlier attempts of the engineer to decorate his bridges by rosettes or buttons of cast iron at the intersections of the bars, or by rearing portals with a lavish display of metal shell work, scrolls of forged iron, and cast and gilded tables of names and dates are also becoming obsolete, and that greater care and reticence are now being devoted even to the design of concrete and reinforced concrete construction.

The artistic architect and the scientific engineer will now agree that a mask of ornamental cast iron, covering the essential features of a structure to force upon it an effect of grace is most illogical. "A form which admits of no explanation, which is mere caprice, cannot be beautiful, and every form which is not inspired by the structure ought to be rejected." Many European bridges fail in respect of æsthetics, because of inappropriate ornamentation, such, for instance, as exaggerated portals highly bedecked with trimmings that outrage good taste. Often in the very process of making structures powerful, compact and economical, the ideals of beauty have been satisfied, without any apparent effort. The ideals are different in the modern battleship to what they were in the old days of Nelson, Dibdin and Campbell, but they are quite as true. The Doric order of architecture would still be beautiful without its sculptured friezes, metopes and pediments, and the latter are only admissible because of their artistic reticence.

It is remarkable that beauty of proportion has often been proved by mathematics, although mathematics allowed to be the only element in the problem has seldom produced beautiful results.

Artistically Designed Structures Not Necessarily Expensive.—There has been a general impression that to ingraft architectural effects upon engineering construction will always involve the necessity for an increased expenditure, but the truth is that it requires the expenditure of more thought than money to obtain artistically designed structures, although at the same time it is a matter requiring special training, and therefore cannot well be done through mere instinct.

In his book referred to above, Mr. Waddell gives the following precepts. A structure must be in harmony with its environment; that is, its general outlines should merge in those of the landscape. A tall church spire, for instance, would not be as suitable on a rocky hill top as a squat tower with no turrets. The sense of abruptness should never strike the observer. Shrubbery may very often be used to merge a structure into the landscape.

Symmetry in the lay-out of bridge spans is always pleasing, and there is little which is so displeasing as unequal spans without apparent necessity for their inequality. But any divergence from symmetry and regularity for which there is an evident reason produces no unfavorable impression. Changes in outline should be abrupt unless there is an apparent reason. The harsh outlines of a cantilever bridge can be relieved by making the chords stimulate a curve, and certainly the straight lines of chords should not intersect each other abruptly.

Ornamentation Must Justify Itself.—Mere ornamentation affronts the sense of fitness, all forms must show some purpose in their general relation, and each part of a structure must be treated in such a way that its function shall be apparent and emphasized according to its importance. As Mr. H. H. Statham said before the Royal Institute of British Architects, "The Tower Bridge represents the vice of tawdriness and pretentiousness, and of falsification of the actual facts of the structure. The exceedingly heavy suspension chains are made to appear to hang on an ornamental stone structure which they would in reality drag down, and capitals are inserted where they have nothing to do with the structure." Ornamentation can have no other justification than that it serves to render clear or to emphasize the function of a member in the structure. Functional efficiency—the ability of any member or detail to perform the duty assigned to it in an efficacious way—is a most valuable criterion.

Many arch spans have recently been built of reinforced concrete which fail artistically because the arch ring is not defined, but is merged in the spandril walls, or in which the skew backs or springings are not defined, or in which the spandril wall is not separated from the handrail by a belt course showing the grade of the roadway, or in which the handrail is not subordinated to the main parts, or in which the piers have not distinctiveness, the fact being ignored that the more important part of the pier is below the springing line.

Method of Treatment Depends on Material.—Different kinds of material used in structures call for different treatment. The advent of a new material with different physical properties from those previously used creates a new standard of æsthetics. This standard once attained, the old standards will gradually be made to conform to the new conditions. Mr. Waddell, in his book, confesses that from an artistic point of view the average American bridge is inferior to the average European structure, and states that while it is advisable for American bridge designers to study carefully European practice in respect of æsthetics, yet they should be cautious to avoid thoughtless imitation, because decorative features which are appropriate to the heavy, massive and costly bridges of Europe would be out of place when engrafted on some of the light, airy, and economic structures characteristic of American bridge engineering.

Mr. J. M. Linton Bogle read a paper some time ago, before the students of the Institution of Civil Engineers, on "The Artistic Responsibilities of the Engineer." In that paper the statement was made that, although engineering structures exerted considerable influence on the lives and character of the people, and were essential to the happiness and very existence of the population, yet the inartistic appearance, and, indeed, ugliness, of engineering works had done incalculable harm to the dignity of the town and to the beauty of the countryside. This author further states that "every common thing which is fittingly designed to express its use and functions adequately is a thing of beauty," but this rather overstates the case, as a common brick or a refuse tin in that case would as such be beautiful. The criticism is, however, truly made that the engineer, impelled by the laudable object of making his work more pleasing, goes further, and applies some form of ornamentation, often without having regard to the important consideration of tradition.

In a material such as stone, we have the experience and traditions of men using it for thousands of years, and for the engineer to be ignorant of, or to ignore, these traditions is to offend against the proportions and the principles which they embody.

Nature the Master Teacher.—Mr. Joseph Husband, in a paper which he read before the Institution of Civil Engineers, entitled "The Æsthetic Treatment of Bridge Structures," points out that nowhere is the fundamental rule of natural beauty of a fittingly designed object better exemplified than in Nature; but, in this case, Nature has almost infinite tradition, or as it may perhaps be better expressed, an infinite development, to work upon. Nature points the way, for in every case the most beautiful and perfect result is obtained by the most economical expenditure of material, and the simplest arrangement of parts for accomplishing the object. Added ornament is not only unnecessary, but entirely foreign to the end in view. The Britannia Bridge makes no pretension to architectural beauty, yet a greater æsthetic success has seldom been achieved. The piers are devoid almost to meanness of architectural detail but their appearance conveys a striking impression of majesty. The carrying up of the piers to a considerable altitude above the girders add greatly to the effect, and the continuity of the girders is suggested, by reason of the perforation of the piers by them. This bridge has really a very strong architectural flavor. Architecture does not necessarily mean ornament, and, with regard to iron structures, it may be accepted as an axiom that where ornament walked in at the door, art flew out at the window. Whether the piers of the Britannia Bridge were made so high that they could be used for suspension chains has nothing to do with the present appearance of the structure.

The servile imitation of architectural detail contributes only to a painfully ludicrous appearance. It seems, indeed, a pity that those responsible for the perpetration of such designs should not have made a sufficient study of architecture, less with a view to its employment than to learn when not to use it. In the discussion which followed the reading of Mr. Husband's paper, it was stated that it took the engineer the greater part of his life to become a master in his science, and it took an architect or an artist the whole of his life to learn something of art. It seemed rather unreasonable to expect that any one man, whether an engineer or an architect, should be able to carry out a work such as a very large bridge with perfect scientific skill and perfect æsthetic taste. On the Alexander III bridge, in Paris, two engineers and two architects had been employed, and have worked amicably together. The very lamp standards were put into the hands of one of the first sculptors of the day. In England they would have been designed in the engineer's office, or perhaps made from an old foundry pattern. French engineers have devoted a great deal more attention to, and have succeeded more admirably in, giving a pleasing effect to their structures than English engineers. Sufficient time and attention is not devoted in the usual case to the study of the appearance, as well as the utility of the works designed by engineers. Clients too frequently have an idea that if a thing is only ugly it must be economical.

It was brought out in the discussion on Mr. Husband's paper that Nature, under no circumstances, knows a straight line, a right angle, or a segment of a curve, without one or other of which architecture is impossible. Nature also sometimes sets her own laws at defiance, decorating apart from constructing, as, for instance, when she puts the stripes on the tiger's back, although these markings may have something to do with concealment. Ornament that is meaningless, that is achieved rapidly, ornament that is not the carefully expressed utterance of the delight the designer felt in the work of his own hands, is not ornament worth having. The application of a castellated form to a bridge pier or abutment is an anachronism which rankles the soul of an artist, and only satisfies an untutored craving for ornament.

Artistic Treatment of Concrete Structure. Professor Beresford Pite, lecturing before the Concrete Institute on "The Æsthetic Treatment of Concrete," said that the simplest and directest royal road to ultimate artistic and architectural success in that material would be reached by eschewing the process implied by the title of his paper. We do not live in the past, though upon it; but nevertheless are necessarily part of the world to which an architectural or æsthetic semblance has importance.

Speaking of reinforced concrete, the question immediately arises whether the provision of a new material, and the application of novel methods of construction, are in themselves sufficient to produce original æsthetic design, fresh in any refreshing sense, having attractiveness and elemental beauty. It is comparatively easy to build in truth, but the problem remains to design it with beauty. Professor Pite, in his paper, remarked that an æsthetically affected and backward looking generation would refuse to be satisfied with unadorned veracities, and would repeatedly demand beauty until something sweet, with the taste of which it was thoroughly familiar, had been stirred into this simple fare.

The architect sets about his task of producing pleasantness of aspect, and, guided by an instructed instinct, he collects ideas, bee-like, out of the material of precedents and motives in the world around him.

There is no common artistic sense or experience which will enable the educated and cultivated world of today to accept the native and naked facts of a reinforced concrete building of ordinary purpose, such as a warehouse or office block, as anything else but barbarous, apart from some harmonious relation to and reflection of traditional architectural forms and proportions which, by long usage and historic meaning have established themselves as alphabets and symbols of artistic expression in the building arts. It would be idle to tell an architect that his reinforced concrete building must be simply true to its material and purpose, and rely only on good proportions for success and artistic effect. Therefore, in the absence of artistic power to educe beauty out of the utilitarian factors of reinforced concrete building, we are compelled to adopt and adapt those past architectural forms which have canons of proportion, and have attained by long acceptance a force of expression.

These architectural forms are of age-long growth and development, and though they come to us in stone and brick, and therefore seem unsuitable and unreal if applied to a novel artificial material, we have none other with which to make that public appeal for sympathy which is the basis of the artistic sentiment. Professor Pite therefore held that we find no instinctive guidance towards an unbiased and fresh originality in the æsthetic treatment of both a novel building material and principles of unusual application, and also that invocations of good proportion, or of other abstract principles, though useful as weapons of criticism, are similarly of no assistance in creating a system of design. He further held that superficial color treatments are insufficient for architectural expression, though valuable in assisting æsthetic effect. But that the texture of concrete surfaces modifies and imparts special character to any forms employed for architectural purposes.

The only method by which definite progress in an architecture of concrete will be possible is by the scholarly and critical employment of the traditional plastic forms of architecture modified by and adapted to execution in concrete, and this is its æsthetic treatment.

In the discussion which followed the reading of Professor Pite's paper, the author disputed the right of engineers to deal æsthetically with any subject without training. He said that they had no more right to sit down and talk about how they designed masses having vertical and horizontal forms than he had any right, as an architect, to discuss with them how he was to design an enormous concrete work. It was when the engineer attempted to be consciously æsthetic that he exposed the cloven hoof. One might have the natural and inevitable results of utilitarian and constructive law accumulating in æsthetic force and value. One might have them in the Forth Bridge or in a gasometer: one had it in the original basis of styles of architecture, but ultimately the language that we spoke, the music that we heard, the architecture that we saw, were the results of a long process, the world-wide historic process of evolutionary form, and it was the doctrine of that evolution which needed understanding.

One speaker referred to a reinforced concrete engineer who stated that he designed beams, slabs and constructional work, but that the lavatory and heating arrangements he left to the architect. This statement showed that this engineer did not understand what architectural treatment meant, nor what were the duties of an architect, and neither did he understand the æsthetic treatment of concrete. Another critic believed in collaboration between the engineer and the architect, but that when one did have an engineer who had a moderate training as an architect, there was no reason why he should not combine both engineering and architecture. One gentleman said that the characteristic feature of reinforced concrete was tension, and that the typical form of construction in that material was the cantilever. Progress would take place in that direction: we should have larger spans and greater cantilevers, and we should then considerably modify our present ideas of proportion.

Professor Pite affirmed emphatically that it was not possible for an engineer who understood something of architecture satisfactorily to deal with the subject, nor that it was possible to imagine certain principles of proportion and apply them to the new material irrespective of architectural examples in other materials. If we departed from the accepted proportions which we derive from traditional architecture, we are completely at sea.

Certain conclusions can be drawn from this valuable discussion on the æsthetics of reinforced concrete. It should not be forgotten that we are working in a cast material just the same as if we were working in cast iron, and that the forms of construction should be suitable for a cast material in the same way that the engineer working with cast metal would give it its own particular forms, suitable to the casting box. No engineer would dream of casting a girder in the form of a steel riveted structure with rivet heads and angle iron connections, and yet the architect sometimes imitates the forms only suitable for brick or stone in his reinforced concrete work. No man by sitting down and thinking can invent a new architectural style. He cannot invent a new style any more than he can invent a new animal.

One remarkable statement made by Professor Pite was that the absence of joints was sufficient to evolve a new style upon and to make it distinguishable from a previous style. Reinforced concrete seems to lend itself to massive styles such as the Egyptian, and to surface decoration styles such as the Saracenic, more than to the constructionally decorated styles such as the Gothic. A flying buttress with pinnacles would seem out of place in reinforced concrete construction, since we know that the reinforcing bars can be placed in such a position that the buttress shall be self-contained, and then, of course, flying buttresses are unnecessary. So also in the case of the dome; the material can be perfectly self-contained, so that the stresses can be provided for without the use of a massive or heavy wall around the base of the dome. A flat roof may be used in reinforced concrete work, since a flat roof can as easily be made waterproof as one of steeper pitch.

It seems a simple expedient for an architect to treat his buildings in the way that an engineer is supposed to treat his structures; that is, to provide for utility only, and then to clothe the naked utility in some way that is pleasing to the eye of the public, but yet not to affect or have reference to any architectural style. But this is, of course, possible no more than it is possible for a man to speak out the expression of his ideas in any other language than that to which he is accustomed; that is, the traditionary language. To this extent, then, is the man bound to act, if he proposes to decorate at all; he is bound to base the work on previous experience on earlier styles, just as a man who speaks cannot do otherwise than speak in words which he has used before, and which he cannot go beyond.

Architectural Element in Engineering Works.—Mr. H. Heathcote Stratham, in a paper read before the Royal Institute of British Architects, said that in the 19th century engineers had played a more important part in the world than architects, and had had opportunities similar to those enjoyed by the architects when the medieval cathedrals were built in the 13th, 14th and 15th centuries. Engineering works, properly so-called, are those in which structural and practical requirements alone are taken into account, without any special consideration of æsthetics, or any special effort at what may be called architectural effect. In a general way, it may be said that it is the effort to make them "ornamental," in the popular sense of the word, which spoils them.

The most serious drawback to iron structures, considered in their relation to scenery, consists in the necessity for painting them. In stone we have a natural material which harmonizes with the landscape; in brick we have a material which takes on tints from weather, and therefore ultimately harmonizes; in the case of iron we are reduced to the paint pot. Simplicity of design, absence of anything like pretentiousness, a simple definition of the practical lines of the structure, are the conditions under which it will have the best effect. Any attempt at artistic or decorative treatment of the Forth Bridge would have been preposterous, and would have defeated its own ends. But there are occasions when an engineering work may fitly be the subject of ornate treatment as a work of architecture.

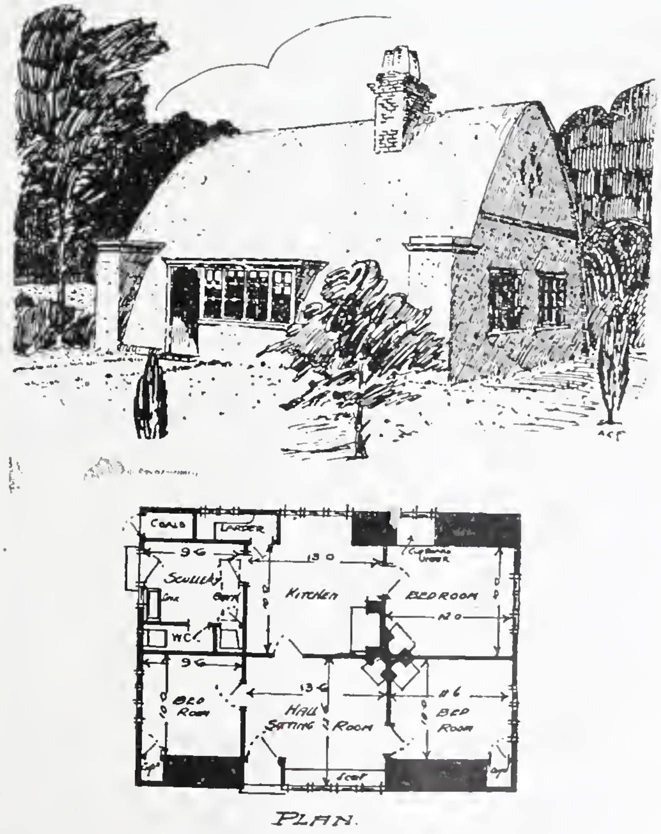
The two mistakes we most frequently meet with in ornate modern engineering works are coarseness of design in ornament and mouldings, and want of perception of scale. Scale may be regarded in two lights. It consists partly in proportioning all the parts and details of a design in such a way that they shall have a harmonious relation to one another; this is perception of scale in the abstract. Conventional scale is the recognized and habitual proportion to each other in details, such as those of the architectural orders, which have by long use come to have a certain recognized relation to one another, so that the use of one of them on an entirely different scale to what we are accustomed to confuses our sense of proportion in the structure.

New Form of Block Work for Building Construction

From The Surveyor, April 25, 1919.

For many months past Mr. Albert C. Freeman, a well-known architect, has been working in conjunction with Mr. E. J. Elgood, of Messrs. E. J. Elgood, Limited, the reinforced concrete contractors, to invent a form of building construction which should be of a permanent character, and with materials within the immediate reach of all housing authorities. Messrs. Freeman and Elgood have now applied for a patent for this new form of reinforced concrete brickwork which is simple in construction and of an inexpensive character. With this invention buildings can be erected in a most efficient, economic and rapid manner, and it is claimed at a considerable less cost than by any other method. This construction is given the name of the "Cat-Ar," deriving its name from the "Catenarian Arch," on the principle of which it is proposed to erect the buildings. It may be mentioned that the Catenarian Arch was adopted by Jacques Germain Soriffiot for the middle dome destined to support the lantern of the Church of Sainte Genevieve at Paris in 1872.

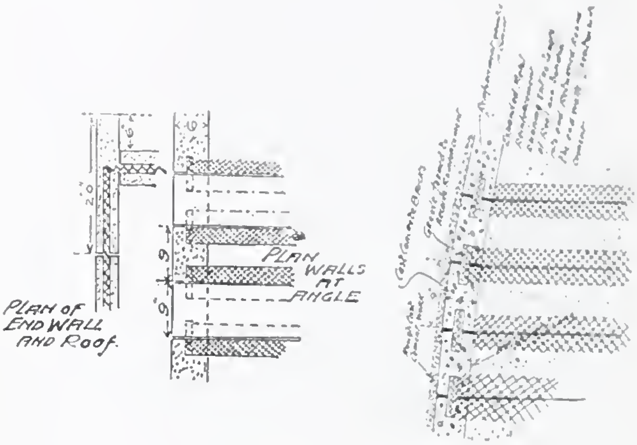
The "Cat-Ar" construction consists of reinforced concrete blocks, size 24 in. by 9 in., and in thicknesses of 6 in. and 4 in. The blocks are cast in machines with hollow cavities 2½ in. deep all round. After being dried and matured they are built up in the same manner as brickwork. The blocks are bedded together with sheets or strips of expanded metal bedded and grouted with cement into the grooves of the respective blocks, both horizontally and vertically. As will be seen from the accompanying illustration, the wall bricks are bonded into the roof bricks, and the reinforcement is continuous, so that the whole structure becomes one solid mass of masonry. The internal walls are reinforced in a like manner and tied into the end walls and the roof. It is claimed that a 6-in. reinforced "Cat-Ar" wall is equal in strength to that of 14 in. of ordinary brickwork. The bricks are strong and rigid, due to the perfect distribution of reinforcing metal, and present a perfect finished appearance from the beginning. The exterior walls can be finished with rough-cast cement-work and give the appearance of age and stability equalled by the old-time stone wall.



Bungalow Type of "Cat-Ar" Construction.

In the design of these buildings the outer side wall will form the roof. The only objection ever made to a concrete roof has been its high cost and weight. The use of reinforced concrete bricks, constructed on the arch principle, overcomes both of these. In the construction the inner walls adjoining the sides of the roof will be constructed perfectly upright and independent. By this means air-chambers will be provided, thus making the building of a more even temperature—cool in summer and warm in winter. The space occupied by the air chambers can be devoted to cupboards, so that no actual floor space is wasted.

The floors and ceiling will be constructed of reinforced concrete beams and slabs, therefore it will be seen that no timber is employed in the construction, with the exception of joinery work for such as doors and window frames and sashes. The roofs and cheeks of all dormers will be constructed of concrete and canopy and hoods over doorways will be treated in a similar manner. The only brickwork employed will be that for chimneys and fire-places. No tiles or slates will be required for the roofs, and no rain-water pipes or gutters will be employed. The rain-water passing from the roofs will be collected in open channels in the ground of the building, and then carried to discharge into a storage tank, to be subsequently used for garden or allotment purposes.



Sections of Walls and Roof.

Causes of Failure in Slag Concrete

Although well made slag concrete is a very reliable building material, there have been cases where concrete, in which slag has been used as an aggregate, has failed. The chief causes of failure were given by Dr. J. E. Stead in a paper read last June before the Cleveland Institution of Engineers as follows: (1) The scrimping of the cement, leaving the finished concrete in a very porous condition, which is not serious in constructions above water level, but where fresh or salt water has free passage into or through the concrete is almost certain to cause disintegration—rapidly by sea water and less so with fresh water. Whatever the aggregate may be, porosity in concrete is certain to lead to premature destruction by sea water. (2) To the use of the fines from old slag dumps, which often contain coal ashes and other deleterious substances. It is therefore desirable to riddle off and reject all that will pass a sieve with ½ in. mesh, or better, the pieces smaller than 1 in. in diameter. Preferably it is safer not to use anything but pure clean slag. Coal ashes are sometimes present in mixed dumps and contain sulphides of iron, which in presence of air and water produce acid solutions which react on the slag, dissolving a portion of the alumina and lime, producing the aluminium-calcium sulphate, which may cause expansion. Concrete floors and pavements have been known to expand and buckle purely owing to the oxidation of the sulphide and production of hydrated calcium sulphate, and possibly due to the production of the double salt just referred to, particularly in cases where care has not been taken to remove the fine slag, and when the concrete has been porous and kept in a damp condition. It is advisable therefore not to use any fine slag at all for floors exposed to such conditions, but employ ordinary sand instead, and in confined positions, such as the floors of dwelling houses, to refrain from using slag as an aggregate owing to the property slag has of yielding sulphured hydrogen when it is moistened.

On the Metallurgical Information Required by Engineers

By LIEUT. COL. C. F. JENKIN.

From Engineering, March 28, 1919.

For the past four years the writer has been responsible for recommending materials for all parts of aeroplanes and aero-engines. In engineering it has been customary to adhere to the use of materials which experience has shown to be suitable for the different parts, but in aircraft a new factor is of paramount importance—viz., weight—with the result that new materials, such, for example, as aluminum alloys, are constantly being suggested and tried for purposes for which they have never before been used. Further, it has become of importance to use all materials in their strongest condition; thus the bulk of the steel used is so treated as to have a strength about double that of the steel used for ordinary engineering work. In order to be able to judge whether a new material (or an old material in a new condition) is suitable for any particular use the following fundamental problem, therefore, becomes of essential importance:

"On what properties of the material does its suitability for any particular purpose depend?"

This question has arisen in connection with all sorts of materials—metals, timber, flax and hemp, rubber, paint, etc., and in connection with their use in engines, aeroplanes, balloons, armament, instruments, etc. To simplify the problem let us confine our attention to metals for use in engines. In order that a metal may be suitable for a particular part of an engine it must possess certain properties which the engineer can easily specify, e.g.:—

1. Stability—i.e., strength to resist deformation (beyond a minute extent).
2. Long Life—i.e., endurance when subjected to stress (of a definite sort) and when subjected to abrasion and corrosion.
3. Special Properties for certain parts—e.g., a low coefficient of friction for bearing metals.

For simplicity we may confine our attention to items 1 and 2. Stability and long life, then, are the properties desired by the engineer; but these are not among the properties which are known to the metallurgist and when the engineer asks for information he is given a very different list of data, viz.:—

Chemical analysis.
Microstructure.
Mechanical tests—ultimate strength, elastic limit, elongation, reduction of area. Bend tests of different sorts. Brinell, scleroscope. Izod. Fatigue range.
Chemical reactions.

There is hardly any correspondence between the two lines. In an attempt to bridge the gap between the two we use a terrible list of vague words to hide our ignorance.

Hardness.
Springiness.
Toughness and brittleness.
Fibrous or crystalline structure.
Resistance to shock or vibration or impact.

Some comparison may be attempted between the two lists by putting them in parallel columns:—

Stability under tensile or compressive stresses	Elastic limit. Scleroscopic hardness.
Stability under bearing pressure (rivet holes, pin holes, ball bearings)	Brinell hardness. Resistance to scratching.
Life under steady stress	Elastic limit.
Life under varying stress	Fatigue range.
Life under abrasion	"Hardness" (one of the meanings).
Life under corrosion	The chemical reactions on which corrosion depends are little understood.
Of no interest to the engineer	Chemical analysis.
Of no interest to the engineer	Microstructure.
Little interest except as giving a margin of strength before final fracture in some steadily-stressed parts	Ultimate strength.
No interest	Elongation.
No interest	Reduction of area.
No interest	Bend test.
No interest	Brinell.
No interest	Izod.

To illustrate the want of correspondence between the two columns let us suppose that it is desired to replace steel by an aluminum alloy for some purpose. It is obvious that it is impossible to make any useful comparison by comparing the analyses or the microstructure of the two metals. It is really useless to compare the ultimate strengths, elongations, reductions of area, Brinell and Izod figures. For consider the elongation. Why do we specify 17 per cent elongation for a steel crankshaft when 1/10 per cent, if it occurred, would ruin it? Is there any reason, then, to specify 17 per cent elongation for an aluminium crankshaft? These apparently important mechanical tests are really no more rational guides than, say, color. As a matter of fact, an experienced eye can judge as well by the color of the steel fracture as by the Izod figure of a fracture. But it is obviously useless to compare steel and aluminum by color.

If the metallurgist's properties are so useless to the engineer, why are so many of them included in the specification? Owing to the lack of knowledge about the life and stability of materials it is not possible to specify such qualities, and the engineer has to specify some definite material which he wishes to use, either for an experiment or as a result of former experience. For this purpose he uses the chemical analysis to define the material, and the microstructure and mechanical tests to define the condition of the material.

What, then, is needed to enable a satisfactory answer to the problem to be given?

1. It is necessary to ascertain what physical properties of the metal they are which determine its behavior under the conditions specified by the engineer.
2. It is necessary to determine tests which shall show the extent to which those physical properties exist in any metal.
3. The names for these properties must be accurately defined.

As an example, consider a crankshaft. It is suggested that the only properties which may need to be considered are:—

1. The fatigue range. The designed stress must not exceed this.
2. Freedom from sharp cracks or faults. Such faults may be due to casting flaws, or to a crystalline structure which encourages surface cracks during machining.

Wearing property may be found to be unnecessary with properly lubricated bearings—if not, this must be added to the list.

All the other properties enumerated on the previous page may be found to have no direct bearing on the suitability of a material for crankshafts. It may be gratifying to a steel maker to see a broken crankshaft twisted into all sorts of shapes after an accident—but why should it not have snapped off like glass?

The above two requirements for a crankshaft may be referred to more elementary properties by the metallurgist. He may be able to indicate the types of solution or crystalline aggregate which are likely to give the desired results. If we could arrive at such a result it would be a great advance on our present position. Such complete solutions have been reached in a few cases, and are certainly not impossible.

As an example of a test properly designed to determine the required property, Strohmeyer's test for the fatigue range may be given. A little further research on this test will probably make it perfectly trustworthy. There is no doubt what it measures.

A satisfactory answer to the problem should not be beyond the reach of the metallurgist and engineer if they work in conjunction. The reason that former attempts have had such relatively unsatisfactory results, appears to be that engineers and metallurgists have not worked together, and that engineers have not fully realized the fundamental nature of the problems they were attacking.

It may be possible to correlate the essential engineering properties with the results given by existing types of test, and it is on these lines that most work has hitherto been done, but more probably new methods of testing will have to be devised. If new methods of testing are needed it is important that they should be designed to give the precise information required. Too many new tests have been devised in recent years without any exact knowledge of what their results signify. As a consequence a great amount of research has been expended in endeavoring to interpret the meaning of the new tests, which research would have been more profitably spent in devising tests to give the essential data.

Collective Systems of Payment by Results

From Engineering, Jan. 17, 1919.

Considerable extension of the systems of payment by results to the engineering industries has taken place within the last two or three years, largely as a result of the stimulus of war conditions, and the present is an opportune time to discuss the trend of such applications and to point out certain of the lessons of experience in operation. Systems of payment by results may conveniently be divided into two broad classes, the individual and the collective systems.

It has been proved repeatedly that in the operation of all systems of payment by results, considerable difficulties will early be experienced and the desired results will be seriously postponed unless the following three fundamental conditions are fulfilled. Firstly, that there must be a sufficiency of work, so that the increased output accruing from enhanced opportunity to attain to higher earnings can be accommodated. Increased output may mean that less men will be required for the work in view, and in such case provision must be made to absorb the surplus so created into other work, also carrying remuneration according to results. It has frequently happened that speeding-up has thrown men idle, and if not paid off, the argument is used that were normal conditions to operate, workers would be paid off. The consequence is a set-back to payment by results. Partly arising out of this condition, payment by results and time work should not be intermittent. This condition of partial application encourages dishonest booking of times against jobs, so falsifying records, and preventing in large measure the full benefits of payment by results from being experienced. Lastly, sufficient knowledge and experience must be available for and applied to the fixing of time limits, piece prices, or standard outputs, which, when once fixed, must not be altered unless the conditions are changed. This last condition is obvious, but success depends very largely upon the application of such knowledge and experience as are generally available. Too generous an estimate leads to temptation to cut rates and so to restriction of output, causes dissatisfaction amongst neighboring workers of equal skill, displaying similar application who, with a normal price, can not earn so much. Tight or scant times and prices are equally bad, cause discontent and tend again towards restriction, since a worker, finding that a reasonable bonus can not be earned, settles down in dissatisfaction to a minimum speed.

In many classes of work severe difficulties are encountered in the initial stages of introduction, and much care, study and patience should be exercised in making the change from time to piece or bonus work. In cases where the three leading conditions have not been sufficiently fulfilled, failure with individual systems has resulted.

With individual systems, it frequently occurs that a percentage of the workers in a shop, who may contribute in part to the successful earning of higher wages by those directly on payment by results, are performing work that cannot be accurately measured and so cannot be dealt with by an individual system. The foregoing considerations have been the cause of considerable extension of the collective system, and in some cases of a change from the individual to the collective system.

The disadvantages of the individual system may be stated to be the amount of work and study involved in fixing up satisfactory standard times or prices for each job and for each individual worker. Furthermore, even with sufficiently accurate times or prices, a certain amount of friction is bound to be set up amongst workers by the fact that the relative capacity of individuals becomes apparent. With faulty rate-fixing the consequences are obvious.

One of the greatest difficulties in practice in the operation of the individual system of payment by results is, as already mentioned, the difficulty of extending an individual system to cover all the workers in any shop. The individual systems of payment by results are well known and have been sufficiently often described to warrant the omission of further explanation. Under the heading "individual systems" are included cases where a number of workers are of necessity engaged in a squad, gang or group upon one job, and where the job is not split up into small components.

The demarcation between individual and collective systems depends in fact upon the extent to which the work is split up. Where a few workers of the same trade work together on a job, at a fixed time or a price, it is not a collective system, but, if the job of building an engine or a set of boilers be given out to a large squad of men perhaps of various trades, it becomes then a collective system. Collective systems have not received the same attention as individual systems. They may be divided into three broad classes. Firstly, where a contract for a certain sum of money, or so many hours, is given to a relatively large number of workers of various trades for carrying out a definite and considerable amount of work sometimes known as the "Contract piecework system." Secondly, where so much bonus or money over and above the time rate is paid to a large number of workers, or to the whole shop, according to the amount of work turned out by this number of workers, or by the shop in a given time. Thirdly, that of profit-sharing. At the present time, we may remark, except in certain cases of piece work, the time rate of wages is customarily guaranteed.

It will be seen that these collective systems of payment by results eradicate certain of the disadvantages of the individual system, in that the whole shop can be given an incentive towards increase of production. One disadvantage which will immediately occur, will be, that whereas with individual systems certain highly skilled workers are encouraged and rewarded according to their skill, with the collective system the encouragement is much less direct. Also the average worker has not the same incentive to speed up as with the individual system, and the best that can be advanced for the collective system is a general leveling-up.

With collective piece work or contract piece work, the contractor will wish to choose the men with whom he will work, which will tend towards the elimination of the less efficient workers; and the functions of the contractor will become, in large measure, those of management, in that he will be interested in the supply of material, and the progressing of work in stages preliminary to his contract. These considerations will naturally become diverted from the foreman or from the management to this contractor. This is not stated necessarily as a disadvantage, but simply as a consequence.

To turn, however, to those systems where the whole shop is working under a collective bonus scheme, this bonus can be paid in two ways. One, when so much per cent over the time rate is paid to every worker for every unit of production turned out per unit of time; and secondly, where so much money is paid in total wages, or so many total hours are allotted to each unit of production and all the workers share in proportion to their time rate, either totally or partially, according to any scale (such as the Halsey, Rowan, etc.), any saving in time or money over the standard hours or price. The first system is obviously wrong. It means that even should a shop be working at only 25 per cent efficiency, some work is being turned out and some bonus over and above the time rate falls to be paid. The second system is correct, in that the fewer the workers' hours per unit of output the larger the bonus per hour per worker. This latter system has been much advocated and extensively adopted in shell and munition works, and has undoubtedly achieved considerable success.

The fixing of the collective output bonus appears much simpler than the rate-fixing required with an individual system. With a collective system the basis is generally to pay bonus in proportion to improvement on past performance without due consideration to the measure of the efficiency of such performance. It is exceedingly difficult to measure the efficiency of a shop without that detailed investigation required by the individual system. With individual systems errors tend to correct themselves. With the collective shop system the error may be much greater. Where practice has been imperfect in the past, it is possible so to fix an output bonus with the collective system, that large wages will be paid, without the requisite rate of production or overall efficiency having been approached, albeit a big improvement on past performance has been achieved. In other words, a proportion of the workers are giving considerably less than 100 per cent output and will take the same percentage bonus as the best worker. The writer has seen collective bonus shops where considerable bonus was being earned, and where on some sections of the machines a proportion of the workers were required to do very little work. Such a state of affairs would not be so readily possible in the case of the individual system, if properly administered, where times, rates and bonuses are not calculated merely in relation to past performance, but where due regard is given to the output that should be possible of attainment.

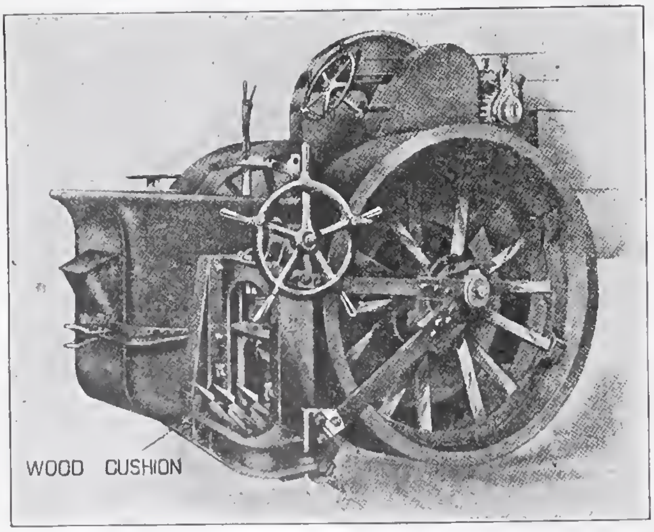
The collective system is popular with the workers, and this is its greatest asset. It is the purpose of these short notes to issue a warning against the complacency with which the improvement resulting from the introduction of collective bonus is generally regarded and to insist on the necessity of that careful individual investigation—inseparable from the best operation of the individual system—in order that we may correctly assess our efficiency performance not in regard to the past, but relatively to and only to the best of which we are capable.

New Road Scarifier

From The Engineer, June 13, 1919.

A form of road scarifier in which special efforts have been made to take full advantage of the weight of the roller to which the machine is attracted, in keeping the tines well into their work, is shown in the accompanying illustration. The scarifier, which is known as the Allen, and which is made by the Oxford Steam Plow Co., Ltd., of Cowley Works, Oxford, also possesses the merits that the stresses which it imposes on the roller are well distributed, while arrangements are made for absorbing, as far as possible, vibrations caused by tearing up the surface of the road.

The view shows how the working point of the tines is brought forward, right under the curve of the rear roller until it is within 2 ft. of the axle, so that as much weight as possible can be brought to bear on the scarifier without putting undue stresses on the tender of the machine. The tines are fixed in a cast steel frame, from which the tool-holders project well forward. A pair of wedges is used to fix each tine in its box and enables the tools being withdrawn upwards, instead of it being necessary, as is the case with some forms of scarifier, to run the roller over a gully or other hollow and draw out the tines downwards. The two wedges are tapered in opposite directions and can thus be tightened or loosened by a hammer from above. The frame of the tool-holder is machined on both faces and slides inside a main casting, which also has machined faces. The main casting is well stiffened by deep ribs and is tied to the outside end of the back axle by a pair of rods, while the bottom, inside, corner is stayed to the fire-box with another stout rod. Besides these attachments the scarifier is bolted to the side and bottom of the tender, with wooden blocks interposed to act as cushions and to localize vibration. On the top of the main casting there is mounted a set of cast steel bevel gearing, for operating the nut of the screw used to force the tines into the road surface.



Allen Road Scarifier.

The Discharge of Large Cast-Iron Pipe-Lines in Relation to Their Age

By ALFRED ATKINSON BARNES.

Abstract of paper read Feb. 25, 1919, before Institute of Civil Engineers.

Dealing first with the general methods of conveying water from a catchment-area by means of aqueducts which combine masonry conduits with cast-iron pipe-lines, the author points out that the sizes of the former portions are usually made, in the first instance, of a capacity sufficient to convey the whole of the anticipated yield.

The pipe-lines, however, are usually laid by instalments, the time-intervals between these being primarily determined by the progressive increase in the consumption of water as found from the town's supply statistics. Hence it is important that the individual discharging capacities of the several pipe-lines should be accurately known from year to year, and the author therefore deals in this paper with the subject of the diminution in those discharging capacities as caused by incrustation.

The paper is an attempt to reduce to a definite law the relation between the effect of incrustation of the mains on the one hand, and the number of years that these have been in use on the other; and the results are based upon observations carried out in the past upon the flow in the pipes of the Thirlmere aqueduct, which supplies Manchester with water from the Lake district.

A table of experiments is given showing the hydraulic gradients and the recorded flow in pipes of 44 in. and 40 in. diameter, after these have been in use for various periods. The results are plotted on a diagram, and a law is given relating the age of the pipes with the diminution in discharge. These diminutions are expressed as percentages of the discharge of a new asphalted pipe, which is presumed to work at the particular net hydraulic gradient which existed during each experiment.

A formula is given for the discharge of the clean asphalted cast-iron pipe, and a diagram is included—based on this formula—from which the quantity passing in pipes ranging from 24 in. to 60 in. in diameter, when new, can be read off.

The author's formula for this clean discharge is:

$$Q = 47.087\ d^{2.769}\ i^{0.529} \text{ cub. ft. per second.}$$

the dimensions being in feet.

The actual flow found by experiment in the incrusted pipe is compared with the flow in the clean pipe as given by the above formula; and the results have led the author to adopt for the pipes in question the following equation, to represent the diminution in discharge with age:

Percentage diminution in discharge $=$ 13 (age of pipe in years)$^{.637}$.

In view of the seriousness of the rate of decrease of flow in the early years, the policy is suggested of adopting some system of cleaning the pipes before the incrustation is very far advanced.

Calculation of Strength of Concrete Columns.—In columns having part of the reinforcement in the form of a spiral wire, as in the Considere system, the strength of the concrete is most satisfactorily calculated by means of the expression $\frac{P}{aF_k\ 15\ F_e}$ where P is the centrally acting force, F_k the cross sectional area of the concrete, F_e the area of the vertical reinforcing bars and a is a coefficient which depends upon the shape of the column. If the height of the column divided by its diameter is x, the following values have been found by experiment:

x	0.8	2.0	6.5
a for hexagonal columns ..	1.3	2.0	3.0
a for square columns	1.3	1.7	1.9

From this it follows that a square column is slightly smaller in area than a polygonal one. The best spiral number for F_k is ½ per cent; this number is more advantageously increased by reducing the distance between the turns of the wire than by increasing the diameter of the wire.—Beton u. Eisen, 1918.

Road and Street Monthly Issue

ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials

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Volume LII. CHICAGO, ILL., AUGUST 6, 1919. Number 6.

Mr. Breed Favors Day Labor Only as a Last Resort

During 1918 the New York Commission of Highways constructed 68 miles of roads by day labor on 15 contracts that were canceled. In his last annual report, H. Eltinge Breed, formerly First Deputy Highway Commissioner, says:

"The work in general was very satisfactory as to speed and quality. The costs were not excessive although we faced a handicap of comparison at the start because most of the contracts were taken at extremely low figures and the contract prices were far below the cost of present day work.

In closing, I will state that it is my belief that such work should not be carried on as a general practice. It places upon the department entirely too great an amount of detail and too much personal responsibility upon the engineers and superintendents handling it. It has proved in the last two years that it is possible and feasible as a last resort for a commissioner of highways. It prevents him from having his hands tied by wilfully obstructive tactics of a surety company, as evidenced in the past by their bidding in completion work at prices far below cost after which no work would be started; and provides the citizens of our State with relief when ordinary methods of procedure fail. When kept down to a minimum and used only in the extremity, the system has proved its value."

In carrying on this day labor work each job was under a superintendent who had been a successful contractor. Such plant as was needed was rented from the superintendent, who was also paid a salary. This plan resulted in as high a degree of efficiency as can be expected under the day labor system, yet Mr. Breed concludes that day labor work "should not be carried on as a general practice." Where civil engineers have been put in charge of construction gangs, the results have usually been unsatisfactory; for, simple as management of men seems, it is an art not acquired in a short time by anyone. Moreover, natural aptitude for handling men efficiently is more rare than is commonly supposed. Educated engineers, perceiving the success of some illiterate men as superintendents, are prone to infer that management is easily and quickly learned by anyone. This is far from true. There are a vast number of "tricks of the trade' to be learned before one can be a successful superintendent. Some of these "tricks" seem never to be thoroughly learned save by men who have risen from the ranks. Perhaps there is also a good deal of truth in the following statement of a successful contractor: "I have learned that a foreman who has never worked with his own hands cannot secure the good will of his men. They regard a soft-handed man as a dude, and will not work for him as hard as for a foreman with calloused mitts. The same holds to a some-

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

what less degree as to superintendents; there is no getting away from the fact that workmen are more sympathetic toward superintendents who have once worked with their hands than toward those whose work has been entirely mental."

Partly in recognition of this fact and partly to inculcate the habit of observing methods, teachers of mining engineering have required mining students to labor under ground as laborers, drillers, muckers, etc., for months at a stretch. Summer schools of practical mining can be studied with profit by teachers of civil engineering, if the object is to train the students to become managers of construction gangs.

High Contract Prices Should Lead Neither to Postponement Nor to Day Labor

It is difficult to realize that the cost of road and street construction has doubled in five years. Consequently when contractors bid twice as high as in 1914, there is a strong inclination to reject all bids. In some cases this leads to postponement of the work till next year. In other cases it leads to construction by day labor. Whichever of these two courses is adopted there will be regret. Wages are rising and prices of materials show no sign of falling. Hence contract prices are apt to be higher next year than now.

Work done by day labor is rarely done as cheaply as by contract. Usually day labor work on roads costs fully 25 per cent more than if done by contract; and not infrequently the cost is double. Men working for a city, county or state simply will not exert themselves as when working for an individual. The editor travels extensively, and wherever he goes is nearly always able to distinguish a "day labor gang" from a "contract gang" at sight. The typical "contract gang" shows far more energy than the typical "day labor gang."

It is frequently said that "day labor work" would always be as efficient as contract work if good managers were in charge, but this is not true. Whoever has been superintendent or foreman over construction forces, both day labor and contract gangs, knows that it is usually impracticable to get a day labor gang to work as vigorously as a contract gang.

"The State is rich. Don't break your back saving a few cents for the State." "Who put the Governor in his soft job? Your votes and mine. Well, the Governor appointed the Commission; the Commission appointed the engineers, and they appointed the foremen. So every last Jack of them owes his job to our votes. Why should we sweat more than the men who owe their jobs to us?" Such is the reasoning of the man that wields the shovel or runs the engine on a day labor job. It is sophistical reasoning, but you can no more convince him of his error than you can persuade a Hindoo that the system of caste is grossly uneconomic.

How City Development Is Hampered by State Laws and Charters

The Legislature of New York grinds out more than a thousand laws annually, of which not 3 per cent are of state-wide application. In other words, 97 per cent of the laws are purely local, and most of them would not be required were the municipalities free to direct their own affairs. Commenting on this condition, Ossian E. Carr, ex-president of the City Managers' Association, said:

"Take it in the city of Geneva in New York: It is necessary for that city to go to the State Legislature in order to increase the salary of the Superintendent of Streets from $75 per month to $90 per month. That is a fair sample of our legislation in New York. It is made necessary by the constitution of the State, and the fact that the cities of the State in their charters specify everything in detail. It permits absolutely no flexibility in administering the affairs of most cities in that state.

"Laws which are passed in Albany to take immediate effect and which do have local application, we sometimes hear about right away and sometimes six months after. Just two weeks ago this was brought very forcibly to my mind. We were selling bonds, or attempting to sell bonds for school purposes. The bonds had already been sold for the erection of schools, amounting to $88,000. On account of the increased prices of labor and materials it was necessary to augment this issue by $15,000 more The local legislation was going through with it in the regular form as provided for in our city charter, and the bonds were duly sold, subject to the opinion of our bond attorneys in New York. About ten days before these bonds were to be delivered our bond attorneys wrote to me and advised me that section so and so of Chapter 868 of the laws of 1917 expressly repealed the provisions of our own city charter placed the previous year, and therefore these bonds were not legal, the defect being that this state-wide law required that no school bonds in a third class city could pass a bond issue in excess of $20,000. Larger sums of indebtedness should be provided for by civic indebtedness. This is a sample of some of our legal problems in the State of New York."

We have commented frequently on city charters that limit city indebtedness to such an extent that economically desirable improvements cannot be made. If engineers wish to be great public benefactors they should study State laws and city charters with a view to outlining a comprehensive plan of reform. Even better than lawyers are engineers qualified to point out the economic defects of existing laws and charters. In many a western city, for example, a paving contractor is unable to secure payment until his entire contract has been completed. This probably results in adding 10 per cent to the contract prices. Such wasteful practices can be speedily eliminated if engineering societies will undertake to do so.

Japan, a Country Without Paved Highways

Samuel Hill, the good roads propagandist, went to Japan last November to show the Japanese Government and people that their economic backwardness is mainly attributable to lack of suitable highways. He has succeeded in organizing a Japanese good roads association that is vigorously working for paved roadways in city and country.

There is not a mile of hard surfaced highway in all Japan, inclusive of the cities. Tokyo, a city of three million people, hasn't an inch of paved street. The inhabitants of cities go shod in stilt-like wooden clogs, or "geta," to keep their feet out of the mud. There are 61,000 miles of Government roads in Japan, but there are few bridges, except over the smallest streams. Nearly all the transportation over the roads is by carts hauled by men and women.

It required no imagination to picture the economic revolution that paved highways and motor vehicles would effect in this nation of dirt roadways. But it did require imagination to conceive that an American enthusiast could change the Japanese practice of trundling their produce through dust and mud. Mr. Hill has shown not only that imagination but the good will and energy needed to make it fruitful. Already a paved road is being built from Yokohama to Tokyo, and others are being planned.

It was America that first opened Japan to the ocean borne commerce of the world. It is an American that has persuaded the Japanese to begin to get rid of their ancient dirt roads. Perhaps some day a statue of Samuel Hill will stand in Tokyo, in gratitude to the persuasive tongue and genial personality that won Japan over to "the good road movement."

Forty Millions for Roads in California

By a vote of 7 to 1 a forty million dollar bond issue for State roads has been carried in California. This will make the per capita expenditure for State roads higher in California than in any other State. Among Western States California has been the leader in liberal appropriations for road construction. In addition to large appropriations by the State, every important county has been equally liberal. It is hard to estimate the value of paved roads to the people of California, but when only one voter in eight opposes such a huge issue it is evident the millions already invested in roads are regarded as having been wisely spent.

Providing Road Funds By Tax on Gasoline

To the Editor:—Several months ago, while sitting at lunch in the hotel at St. Catharines, Ontario, I got talking with a stranger about good roads and the means of raising money for them. He suggested that a tax on gasoline used in motor vehicles would be the most equitable means of raising funds. A little later, in looking through my files of literature on paving and road making, I ran across an article by Mr. Clifford Richardson, written many years ago, in which he discussed the same matter.

Some months past, I wrote an article suggesting the "Wheel Tax," which many of the magazines published. There is some analogy between the wheel tax and the gasoline or fuel tax, as both try to secure the money from the actual user of the road in some proportion to the service they receive.

An annual tax on the "wheel" would not take into consideration how much the vehicle having the wheel was used during the year; while a tax on the "gas" would be in direct relationship to the actual use on the road. The more a vehicle is operated, naturally, the more gas it requires; also, the heavier the vehicle, the greater amount of gas it consumes per mile. Therefore, a tax on gas would most equitably compensate for the destructive use of the road by the owner of the vehicle.

The "gas" tax would, of course, present some difficulty. Means would have to be found for taxing vehicles not using gas; and there would surely be other flies in the ointment. One of these would be the necessity of the province or state carefully supervising the distribution of gasoline to users of road vehicles.

As the matter of raising money for road improvement seems to be the greatest stumbling block in the way of "good road" management and construction, it seems to me that this is a very vital issue to-day. I would like to see a much more exhaustive discussion on the subject of taxation for good roads than we have yet had.

C. A. MULLEN
Director of Paving Department
Montreal, Que. Milton Hersey Co., Ltd.

Methods of Letting Contract Work.

To the Editor: Attention is directed to article on page 89 of Engineering & Contracting for July 23, headed "Advantages and Disadvantages of Various Methods of Letting Contract Work," by J. A. L. Waddell.

In the above mentioned article Mr. Waddell states that the best manner for letting contracts on the co-operative basis is a modification of the Graff Method. If we understand this method correctly, it is simply a sliding percentage scale contract with a maximum guaranteed cost to the owner. When a contractor bids on any work, is low bidder and is awarded the contract, he must divide his profit, if any, with the owner, and if he loses he has no protection whatever.

Is it not true that the best contract that can be executed is the one that obtains for the owner the lowest price for the work? Is it not also a fact that the contract which will obtain from the contractor his lowest figure is the one that is equitable to the contractor as well as the owner and will protect the contractor in the case of unforeseen contingencies? Where is the justice in any contract which requires that the contractor shall assume all the gamble and the owner be fully protected?

Under the Graff Method, if a contractor expected to make 10 per cent profit, he must figure a 20 per cent profit on the work in order to divide such profit with the owner and still retain his 10 per cent. What is the advantage of deceiving the owner in this manner?

We have done considerable straight percentage work and have not a single dissatisfied client, and it is not our experience that work cannot be done as cheaply under a percentage contract as by the lump sum method. We believe from observation you will find that in most cases where percentage contracts run excessively high, it is due to the fact that the engineers in charge of that work assume all authority on the job and take the actual construction work out of the hands of the contractor, which naturally will make the work cost considerably more for the reason that a contractor cannot take the interest in reducing the cost where he is not allowed to handle his organization.

We believe that the best contract written, for the owner, under the present uncertain labor and material conditions, is one which provides for the payment of the actual cost plus a fixed sum for supervision and profit. When a contractor's fee is fixed, his only interest is to satisfy the owner and get the job done as quickly as possible, and the way to satisfy the owner is to reduce the cost.

The best co-operative contract we have seen, in our opinion, is the one described on page 409 of Engineering & Contracting for April 23, prepared by Harrington, Howard & Ash, Kansas City, Mo., in which bids are received on a cost plus a fixed fee basis. If the actual cost is less than that estimated by the contractor the amount is distributed equally between the owner and the contractor; if the actual cost is more than that estimated by the contractor, the contractor is paid his profit fee less one-half the amount which the actual cost of the work is in excess of the contractor's estimated cost, but in no event shall the contractor be paid less than the actual cost of the work plus one-third of the contractor's profit fee.

Bonding companies claim that a percentage contract with a guaranteed cost is the most unsatisfactory contract that can be written from the contractor's viewpoint, and rightly so.

A. J. M'KENZIE,
Vice President and General Manager McKenzie Construction Co.
San Antonio, Tex.

Half Section Plan of Road Construction

The State Highway Department of Pennsylvania has issued the following statement outlining its reasons for not ordering the construction of new highways in half sections, so that half of the road can be used while the other half is being built:

"The half-section plan of construction is impracticable and not economical in Pennsylvania, in the building of modern-type pavements, because of the general narrowness of Pennsylvania thoroughfares. Roads so constructed would not give satisfaction, inasmuch as it would not be possible to avoid variable conditions in the construction of the two sides.

"Contractors will bid much higher on this type of construction, because they would have to cover the length of the road twice, instead of once. Materials can only be stored in one half the road.

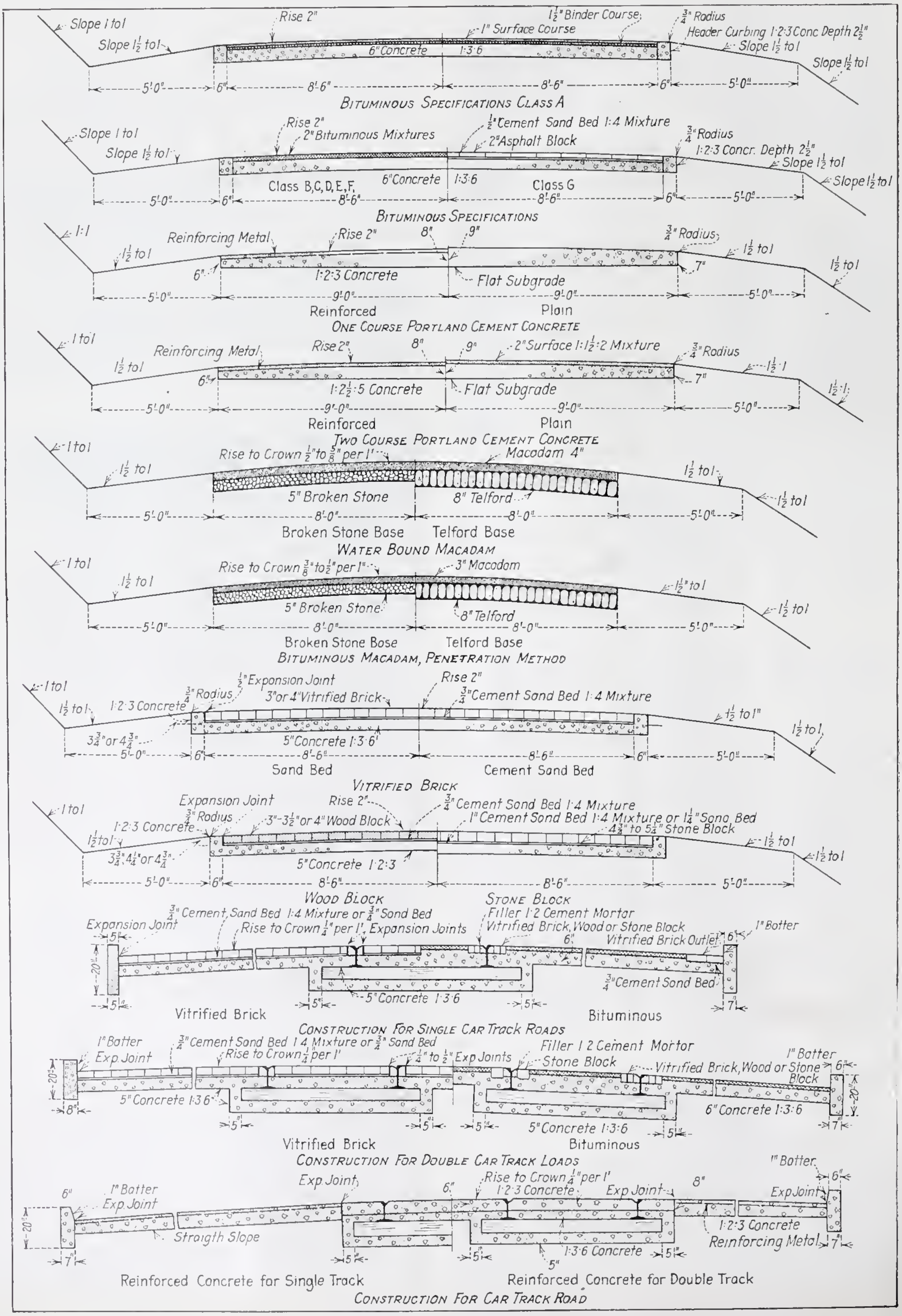
"Especially where the road is dusty there is a marked disadvantage in using a half-wide section, because the materials become dirty, not only from the dust, but from dirt thrown up by traffic.

"The congested right-of-way—that is, the small width from fence line to fence line, as well as the width necessary for heavy grading on most Pennsylvania roads, mitigate against half-way construction. Contractors would be handicapped through traffic tying up grading operations. And Pennsylvania roads carry more bridges which would have to be rebuilt than do most other states.

"Most of the construction on the state's primary system cannot be classed as resurfacing. In discussing the half-width idea, the only economical and reasonable way, so far as the state is concerned—and most certainly the contractor, is to eliminate traffic from the section being reconstructed. Both time and money are saved. Any other course would be poor housekeeping."

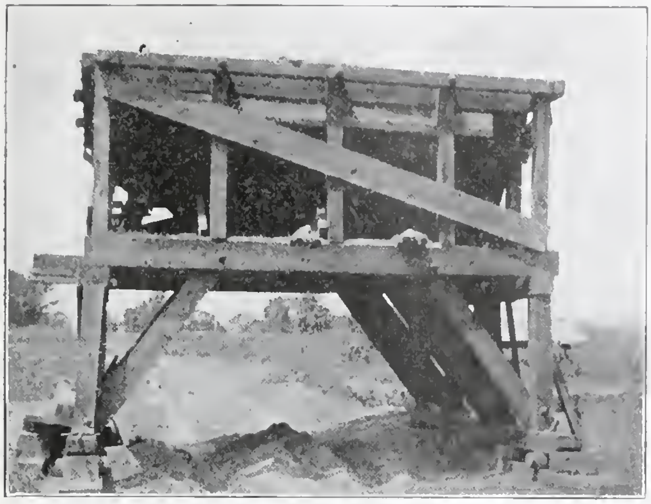
Improved Roads Save $1 per Day for Each User.—The improved roads of Milwaukee County, Wisconsin, save $25,000 a day to the people who use them, according to the estimate of the county commissioner of highways, as reported to the Bureau of Public Roads of the United States Department of Agriculture. The statistics are based on a census of the traffic taken periodically during the past four years. The census is made by selecting 52 points scattered throughout the county, and making seven counts at each point, one for every day of the week. The count is not made on consecutive days, but at various periods from April to November, so as to arrive at average conditions. This census is taken to determine the durability of certain types of pavement, according to the amounts of traffic a square yard. It shows that about 25,000 vehicles of all kinds travel the highways each day. Traffic on the road has increased about 42 per cent a year during the four years in which the census has been taken.

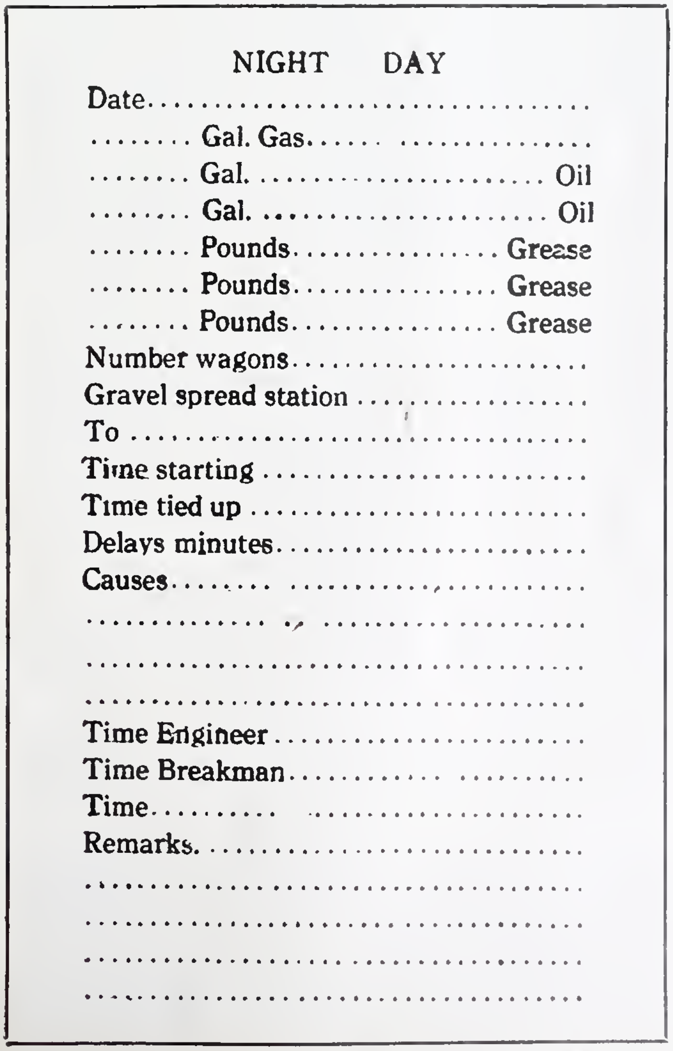
Standard Sections of State Highway Department of Pennsylvania for Road Pavements



Tractor-Trailer Outfit Kept in Continuous Operation Hauling Gravel

In connection with their contract for constructing gravel roads in Wabasha county, Minn., the contractors, A. Guthrie & Co., St. Paul, Minn., are operating a tractor-trailer outfit day and night in hauling gravel. The outfit consists of five 4 cu. yd. Troy trailers and a 120 hp. heavy artillery type Holt caterpiller tractor. The hauling is being done over a dirt road and a speed of 2 miles per hour on low gear and 3 miles on high is obtained.


Movable Gravel Storage Bin.


NIGHT DAY

Date................................

.... Gal. Gas...... ....

.... Gal. .... Oil

.... Gal. .... Oil

.... Pounds............... Grease

.... Pounds............... Grease

.... Pounds............... Grease

Number wagons......................

Gravel spread station ....

To ....

Time starting ....

Time tied up ....

Delays minutes........................

Causes........ ....

....

....

....

Time Engineer........................

Time Breakman............ ....

Time.......... ....

Remarks.............................

....

....

....

....

Blank for Recording Tractor Operations (Actual Size $2\frac{3}{4}$x5 In.).

The gravel is excavated from a long surface pit by means of a drag line which loads into a 40 cu. yd. capacity storage bin. This bin is supported on rollers, as shown in the illustration, so that it can be moved along as the drag line is advanced. The bin is equipped with two gates, one loading into the front end of the trailer and the other into the rear end. This arrangement makes it unnecessary to move the train while the particular car under the gates is being filled.

The gravel is dumped on the grade of the road to be improved and later is spread with a road machine and drag.

Night and day shifts are worked on the drag line, two men being employed for each shift. Two men also are employed on the train for each shift. The hauling outfit is kept in practically continuous operation. To do this the night crew is taken out in a Ford to meet the train, and the day crew is brought back in the same car.

The simple blank illustrated is used for recording operations of the tractor. This is filled out by the engineman and turned in each day. The blank is printed on cheap paper and assembled in the form of a pad.

Cost of Earth Road Maintenance with Tractor Outfit and with Mule Outfit

The following data from the daily cost and progress report of the Highway Commission of Cherokee County, South Carolina, give comparative figures on the cost of maintaining roads in that county with a tractor outfit and with an 8-mule outfit. The tractor outfit consists of a 15-25 Lauson tractor and two 7-ft. blade road machines. With this outfit 9 miles of road were covered, four breadths of blade, in a 10-hour day. The daily operating cost based on 24 work days in a 30-day month was as follows:

Kerosine, 20 gals. at 15 ct	$ 3.00
Gasoline, 1 gal. at 26 ct	.26
Oil, 1 gal. at 75 ct	.75
Interest on equipment	1.00
Repairs	1.00
Engineman	3.50
Machine operators: 1 at $4.50, 1 at $3	7.50
Total cost per day	$17.01
Cost per mile at 9 miles per day	$1.89

The mule outfit, consisting of 8 mules and two standard road machines, covered 10 miles of road, four breadths of blade, in 10 hours. The daily operating cost, based on 24 work days in a 30-day month, was as follows:

8 mules at $1.25	$10.00
2 drivers at $2.50	5.00
Interest on equipment	1.00
Repairs and shoeing	1.80
Machine operators: 1 at $4.50, 1 at $3	7.50
Total cost per day	$25.30
Cost per mile at 10 miles per day	$2.53

The costs using a 3-way drag or leveler are as follows:

The tractor will cover 9 miles twice over in 10 hours at a cost per day of $12.01, or $1.334 per mile.

A 6-mule outfit will drag 10 miles twice over in 10 hours at a cost per day of $18, or $1.80 per mile.

Mr. N. C. Hughes, Jr., Engineer of the County Highway Commission, who furnished the above data, also states that when the occasion demands the use of a scarifier, one made to attach to an engine drawn road machine, there is no comparison between team power and horse power, the difference in the cost of operation being so much in the tractor's favor.

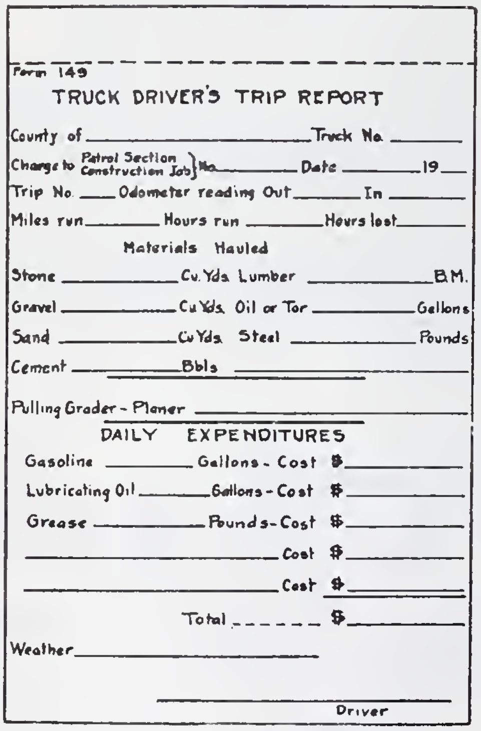
Mr. Hughes also writes that for maintaining a system of highways an all tractor outfit or an all team outfit is an unbalanced proposition. Both, in his opinion, are needed to coordinate each other, for there are certain phases which arise in maintenance of roads to handle which one or the other will prove not suitable.

Settling Road Fills by Puddling.—The ponding method of curing concrete roads, which originated in California, is now being employed in that state for settling road fills. By this method an earth dike about 12 in. high is built along the extreme outer edges of the fill. Cross dikes of the same height are then thrown up at intervals of 6 to 10 ft. To aid in distributing the water through the material holes are bored through the fill with a post hole auger. Each ponding area is then filled with water to within 2 in. of the top of the lowest dike. The areas are refilled with water two or three times or until settlement appears to have ceased. On heavy adobe or clay fills, care must be taken not to introduce an excess of water, especially if the season is late.

Lessons from 1918 Experiences of Patrol System of Road Maintenance in Wisconsin

Since May 1, 1918, the 5,000-mile state trunk highway system of Wisconsin has been maintained by the counties in accordance with the directions and specifications and to the satisfaction of the State Highway Commission. The maintenance is carried out under the patrol system, supplemented in practically all counties by small gangs for reconstruction and heavy repair work. The commission has recently issued a bulletin, compiled by Mr. J. T. Donaghey, State Maintenance Engineer, outlining the ideas successfully put in operation and the lessons learned in the 1918 maintenance work. The matter following is reprinted from the bulletin.

Lessons Learned from 1918 Maintenance Experience.—A poor earth road may be changed to a good one for from $100 to $300 per mile by the use of a heavy blade grader and large tractor.



Form 149

TRUCK DRIVER'S TRIP REPORT

County of ________ Truck No. ________

Charge to Patrol Section / Construction Job No. ________ Date ________ 19___

Trip No. ____ Odometer reading Out ________ In ________

Miles run ________ Hours run ________ Hours lost ________

Materials Hauled

Stone ________ Cu. Yds. Lumber ________ B.M.

Gravel ________ Cu. Yds. Oil or Tar ________ Gallons

Sand ________ Cu. Yds. Steel ________ Pounds

Cement ________ Bbls ________

Pulling Grader - Planer ________

DAILY EXPENDITURES

Gasoline ________ Gallons - Cost $________

Lubricating Oil ________ Gallons - Cost $________

Grease ________ Pounds - Cost $________

________ Cost $________

________ Cost $________

Total ------- $________

Weather ________

____
Driver

Fig. 1—Blank Designed by Wisconsin Highway Commission for Recording Cost of Motor Truck Operations.

Width and smoothness of surface are of more importance than low grades.

Where a patrol maintenance system is in operation, no road should have more than a 4 to 6 in. crown for a 24-ft. shoulder to shoulder roadway.

An application of 2 to 3 in. of sandy gravel, not larger than ¾ in. in size, on the surface of a clay road will give excellent results. Small stock piles of the material should be deposited along the roadside for the patrolman's use in strengthening the weak places. Ruts will occur, but persistent light grading or planing will result in an excellent and cheap temporary surface.

Many roads ordinarily called "sand roads" can be converted into very satisfactory roads for light traffic by moving in to the center with a blade grader the new top soil from the roadside for a wearing surface and keeping the surface smooth with a grader or planer. The bad sand requires a mixture of clay if available; if not, a covering of cedar shavings, marsh hay, straw, fine brush or weeds.

The patrol sections should not exceed 8 miles in length for team patrol and that the patrolman should live on the section and as near the center of his section as possible. Where a competent patrolman can not be secured who lives near the center of a section, it is economy for counties to build a shack for the patrolman to be located near the center of the section. The saving of time will repay the cost of the shack in two seasons or less.

The best single tool for the patrolman's use in keeping the road surface smooth is the 4-wheeled, 2-horse road grader. Next is the road planer.

A wavy, uneven gravel road can be scarified and then reshaped with a grader at a cost of from $50 to $75 per mile, resulting in an excellent road. If new material is required it must be of a size passing a one-inch ring.

A 9 ft. gravel or macadam road can be scarified and widened to a 16 ft. width by covering the old surface and 3½ ft. of each shoulder with from 2 to 3 in. of fine gravel. The persistent use of the light grader or planer will produce a well compacted surface without the use of a roller. This is both an excellent and cheap method.

A 9 ft. stone or gravel macadam road can be successfully widened to a 16 ft. width by resurfacing with 2 to 3 in. of stone, extending the stone over 3½ ft. of each shoulder and binding the new material with bitumen. If the road is properly constructed, the 3 in. depth of stone on the shoulder will amply care for reasonably heavy traffic.

A badly worn macadam surface can be maintained more cheaply by the application of about 2 in. of sand and that this will result in a more satisfactory road to travel than if a surface treatment is applied. It must be gone over frequently with the road grader or planer.

No road should receive a bituminous surface treatment except where the surface is smooth and clean and that when bitumen is used it should be of a quality and of a sufficient quantity to penetrate the road surface thoroughly. Holes appearing in the surface should be patched immediately by the patrolman. It is a waste of funds to apply surface treatments and not use an absorbent of stone chips, pea gravel or torpedo sand. The surface treatment of roads taking care of heavy traffic, that have been previously treated, should be continued, provided they have been properly maintained.

Plans for Future Maintenance.—Based upon the results obtained in 1918 by "heavy blade grader work," the commission plans to improve every mile of road on the system by that method, except, possibly, the former state aid work, within the next three years.

The benefits derived from having the entire system well-drained and graded to a safe width for travel (24 ft from shoulder to shoulder) can hardly be estimated. The factor of safety alone is worth the cost. The very worst sections were graded in 1918, the next worst will be taken care of in 1919, and this work will be continued each year until the whole system is properly graded.

Heavy clay roads which cannot be covered with a high type of surfacing within the next 2 or 3 years will be covered with 2 or 3 in. of fine gravel, if available within a reasonable haul.

Practically all gravel roads not surface treated, as well as many miles of macadam, will be scarified and reshaped at least once a year. The best time for this work is early in the season.

Motor Trucks in Patrol Maintenance.—The commission does not encourage the use of motor trucks for patrol maintenance. However, each county should own one or more 2 to 3½ ton trucks for delivering material to the patrolmen, where the maintenance material must be hauled a distance of 2 miles or more during the summer season. A good team of horses or mules can perform any and all work on a patrol section that can be done with a motor truck, but in many instances not as fast. On the other hand, a team can do numerous kinds of work that cannot be done with the truck. A motor truck to be profitable to the owner must be constantly in use. This is not possible on patrol maintenance. The team or truck must stand by the roadside a large percentage of the time while the patrolman is doing handwork.

There are several counties where the type of road and existing conditions warrant the use of motor trucks for patrol work. In such counties the commission will insist upon the patrolman doing only such work with the truck as can be done economically. Teams must be used to do the natural team work. We doubt very much if there is one county in the state using motor trucks for either construction or maintenance work that knows the true unit cost of operating the trucks, which cost must allow for depreciation and upkeep, as well as for cost of operation.

The form (Fig. 1) has been devised for the express purpose of keeping the true cost of motor truck operations. Each construction job or patrol section is charged with the work performed by each truck, the truck being credited with the same. The fixed and operating costs of each truck are charged to the individual truck. This method places each truck on a business basis. The same method is employed in keeping tractor costs.

Counties having gravel available, even though at long hauls, should plan to haul at least a portion of the necessary maintenance material during the winter. The material will then be at hand for the patrolman to care for the "bad spots" as the frost is leaving in the spring.

Cost of Street Cleaning at St. Paul, Minn.

Cost of Hand Sweeping.—The city of St. Paul has an area of 55.44 square miles, of which 3.27 is water. There are 91 miles of paved streets, 5¾ miles of paved alleys, 45 miles of macadam streets, 13 miles of gravel; and 395 miles of roads graded only and 22 miles of alleys graded only. The paved area, streets, bridges and alleys amounts to 2,339,122 sq. yd. Of this 58 miles or 1,347,051 sq. yd. of paved streets are cleaned by hand sweeping. The force in 1918 consisted of an inspector at $115 per month, assistant inspector at $90 per month, 105 to 125 sweepers and 15 shovelers at 27½ ct. per hour and 14 teams at 75 ct. per hour; all working 8 hours.

According to the last annual report of M. N. Goss, Commissioner of Public Works, the total cost in 1918 of hand sweeping this district, including the shovelers and the hauling away of street-sweepings averaged $67.23 per 1,000 sq. yd. for the season. Each sweeper in uniform is assigned to a district and sweeps and patrols 3,200 to 17,600 sq. yd.

In the business district paved alleys are swept once a week by the sweeping crew, two teams and four men being assigned to this work. The rubbish receptacles at street corners have their contents removed by a single team and one or two men to assist.

Street Flushing.—The streets in that portion of the business district bounded by St. Peter, Eighth, Third and Broadway, are flushed every night during the season. There are 7.12 miles of streets, or a paved area of 146,400 sq. yd. in this district. Three Studebaker flushers are used on this work; the crew consists of a foreman, three teamsters, and two gutter cleaners—they work eight hours. The average cost in 1918 of operating one flusher on this night service was $11.52; the cost per mile per night is $4.85, and the cost per 1,000 yd. 23.6 ct. These costs include pay-roll, oil, waste, gasoline and water, but no repairs to equipment. Seven Studebaker flushers are owned by the city, and six are operated continuously on day shifts on streets outside of the district above described—they work nine hours.

Cost of Squeegeeing.—Seven squeegees or scrubbing machines are owned by the city and are used on smooth pavements, such as asphalt, asphaltic concrete, and creosoted block, with success.

The average cost of squeegeeing in the business district, outside of the "night district" was 19.4 ct. per 1,000 sq. yd. and in the residence district 34.6 ct. per 1,000 sq. yd. for one scrubbing; the higher cost in the residence district is due to the necessity of having the squeegees followed by a pick-up wagon to clean up the gutters, and in the downtown district, this service is performed by the teams hauling street sweepings.

All paved streets in the residence district are either flushed or scrubbed once a week and oftener where necessary.

Oregon Society of Engineers Votes to Amalgamate with American Association of Engineers.—By unanimous vote on July 24 the Oregon Society of Engineers decided to amalgamate with the American Association of Engineers. Other societies that expect to vote upon amalgamation in the near future are the Engineers' Club of Kansas City, the Engineers and Architects' Association of Southern California, the Southwestern Society of Engineers and the Houston Engineers' Club. The question of amalgamation has been initiated by several other societies and is now under consideration by them.

California Votes $40,000,000 for Completing Its Main Highway System.—By a vote of 7 to 1 the citizens of California authorized a $40,000,000 bond issue for the completion of the main highway system. There will be a further $10,000,000 spent by counties, who have already voted their bonds and about $10,000,000 of Federal aid will be expended to certain post roads. This makes a total of some $60,000,000 to cover a program that will take some three years.

How to Provide a County with Good Roads

The improvement of county roads has become so urgent to properly develop the resources of the country, it is necessary for the authorities and citizens to devise ways and means of bringing such a development about. The following plan for accomplishing this is suggested by the Highway Industries Association:

In undertaking this improvement, a number of important features have to be taken into consideration and given careful study. The entire road mileage of the county must be ascertained; the number of miles of roads that it will be advisable to improve, the character of the traffic, that passes over each road; an estimate of future traffic; the ability of the county to raise sufficient funds to improve the mileage selected; and the methods in which this money can be raised.

A close study should be made of the present taxable basis, and the financial obligations of the county, the tax rate, and the amount it would increase the tax rate to build the roads by a direct tax or by bonds. The financial ability of the county having been ascertained, the approximate amount of money the county can raise by bonds or otherwise determined, and the roads classified, a system can be laid out in keeping with the amount of money to be expended with adequate provisions for maintenance.

It is most important that a close study be made of the existing roads, a system laid out, and the cost of improving such a system determined. In estimating the cost, provision should be made for future maintenance so that the burden placed on the county would not be such as to raise the annual tax above that prescribed by law or become burdensome to the taxpayer.

Bonds should be of the serial variety, life not exceeding 25 years, preferably 20 years, and bearing a rate of interest that will make them attractive to investors.

The roads selected should be so co-ordinated as to form a complete system, connecting up the most important points and railroad stations in the county. If the county has no county engineer, the services of an experienced road engineer should be secured to lay out the system, and make an estimate of its cost of construction, and maintenance.

The system of roads having been selected and laid out, cost of construction ascertained, and the financial ability of the county being found capable of constructing such a system, it will then be necessary to plan a campaign of information and education, so that when the issue is put before the voters it will be clearly understood, and the great benefit to be derived may be fully known to every voter.

The best way to bring this about is to form a good roads organization such as a county good roads association, elect a chairman, a vice-chairman, for each district of the county, and a secretary. Under a vice-chairman each district should form a committee, bringing together as many people as possible who will work for the passage of the bond issue or special law by calling the attention of the members of the legislature, and all the people to the great need for improved roads and the benefit that will be derived therefrom. The committee should extend their activities to each community in the district by holding meetings and sending out literature, setting forth clearly the object of the campaign and what it hopes to accomplish.

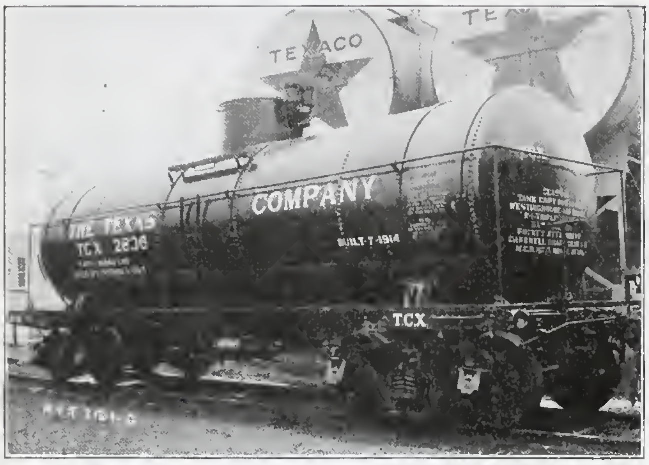
License Examinations for Idaho Engineers.—The enforcement of regulations governing the practice of surveying and civil engineering in Idaho now comes under the Commissioner of Law Enforcement, R. O. Jones, Boise, Idaho. There is now a law regulating the practice of civil engineering in Idaho which appears to include all branches except mining and metallurgy. Examination for civil engineers will be held the second Tuesday in September and that of surveyors the first Tuesday in September. No survey of land or plat of same has been legal since June 1, 1903, unless made by a licensed surveyor.

Next Convention of the American Road Builders' Association.—The board of directors of the American Road Builders' Association have decided to hold the next convention of the association at Louisville, Ky., Feb. 9-13, 1920. Both the sessions of the convention and the exhibition will be accommodated in the First Regiment Armory, which is situated within two or three blocks of the leading hotels of the city

The Advantages of Tank Car Shipments of Asphalt

By CHARLES E. MURPHY,
Asphalt Sales Department, The Texas Company.

Tank car shipments of asphalt have increased so remarkably during the last few years that it now seems timely to review some of the reasons for this increase. The first and paramount reasons are that tank car shipments have given universal satisfaction, they have proved to be economical, have reduced considerably the labor of transportation, and that where possible to be used they have effected quicker, safer and easier handling of the material.



Modern Tank Car Near Loading Stations at Refinery Preparatory to Being Filled with Asphalt.

From the viewpoint of economy, shipment of asphalt by tank car may be considered from several different aspects, under the following headings: Original cost. It is unnecessary to pay for containers and the freight on same. There are no barrels to be stripped, and the amount of manhandling of the material is negligible. There is no necessity for storage space to put barrels or drums. Problems of disposing of empty barrels or drums is eliminated.

Considering the first aspect, it is obvious that the original cost of the material is considerably reduced by tank car shipment, because the cost of handling at the refinery is less. The cars are placed at the valve houses at the refinery and are loaded mechanically through pipe lines running directly to the storage tanks. Contrast this with the method of shipment in barrels or drums, where considerable human labor is required, and much time is consumed in the packing operation. In the tank car method all this is obviated, and the natural result is a more economical output.

Road Oil Distributor Being Loaded from Tank Car by Hand-Pump Method. Handle of Pump May Be Seen at Top of Photograph.

No Cost for Containers.—In discussing the second phase of the question from an economical viewpoint, there is more than the fact that the consumer does not have to pay the cost of the containers. He pays for the net asphalt only. He gives nothing for the use of the tank car, unless it be retained more than 48 hours, when a demurrage charge is made. This charge is not asked so much for the use of the car as for a guarantee of its early return. In comparing this with the cost of barrels, for which of necessity a charge must be made, one must also consider the freight charge on these containers.

Under the third heading stating that there are no barrels to be stripped, one should consider the ease and economy with which the asphalt is pumped from the tank cars in comparison with the extensive labor required in handling containers. The material may be pumped with facility direct from the car to the storage plant, which operation demands a small amount of manhandling.

Storage Problem Obviated.—The problem of providing storage space for drums and barrels is usually one that entails time, effort, and expense. Furthermore, it must be apparent to all that after the barrels or drums have been emptied, their disposal is sometimes a troublesome matter. Oftentimes, it is possible to return them to the seller, who gives a small remuneration, but in such cases the containers must necessarily be in usable condition.

One of the phases of tank car shipments which usually perplex consumers is the process of heating the asphalt for removal from the tank cars. The expansion caused by heating an 8,000-gal. tank car to a temperature of 300 to 350° for unloading varies between 9 and 10½ per cent of the original gallonage. From an actual test it has been determined that in the heating of asphalt in tank cars there is an increased expansion of 0.00035 per degree in temperature above 60°. Thus in heating asphalt in a tank car 360° for unloading, the gallonage would be increased approximately 10½ per cent. Therefore it is necessary to load a tank car only to within about 10½ per cent of its capacity. It should not be necessary under normal conditions to heat a tank car containing from 50 to 60 penetration material much over 300°; that is, if the car is unloaded with an efficient pump and the distance to which the material is pumped is short.

Auto-Distributor Being Loaded with Asphalt from Tank Car by Pressure Supplied by the Automobile. This Process Is More Modern Than the Hand-Pump Method.

Rules for Unloading.—Below are a few general rules which, if followed judiciously, will result in easy unloading of asphalt from tank cars:

When there is a steam connection on top of the shell, this connection should be used for the inlet and the bottom connection for the outlet. After the steam is connected, do not open the valve wide all at once but turn it on very slowly, taking ten to fifteen minutes to get steam through the entire coil. This permits the coil to heat up gradually thereby causing minimum strain on the coil.

Before turning on steam the outlet valve of the steam coil should be opened wide, to blow out any water that may be in the coil. Later, when the coils are clear of water and warm, the valve should be properly regulated to prevent waste of steam.

Always remove the dome cover before turning on the steam.

Do not allow moisture to enter the car from the outside, through the dome. If it is raining or snowing when unloading arrange a suitable cover so that any moisture on the inside of the car will have a chance to get out in the form of steam, and so there will be no danger of moisture getting into the asphalt through the dome.

Both the contents of the car and the exhaust from the outlet valve should be frequently inspected to: First, see that the asphalt is not foaming; second, see that the coil is working properly.

If the asphalt should rise in the dome and show a tendency to foam over, the steam should be turned off in plenty of time to permit the asphalt to settle back, and the steam can be turned on again; and by working carefully in this manner any cause for trouble will be eliminated where there are only traces of moisture. In such cases use a thermometer and keep temperature just below 190° F. until the moisture is worked out.

Also, if it is found that the contents of the car contains moisture or that there is a small leak in the coil, the car contains moisture or that there is a small leak in the coil, the car may be unloaded in most cases, provided dry compressed air is available. A perforated pipe should be lowered into the inside of the car through the dome, placed on the bottom of the car and attached to the compressed air line. A small amount of air applied in this manner has a tendency to drive moisture out of the asphalt without excessive foaming.

Any bubbling of steam up through the asphalt indicates a leak in the coils of more or less extent. The steam should be turned off immediately, and after cooling about 15 minutes should be turned on first one coil and then the other to determine which coil is defective. Steam should not be kept on a defective coil, as it will condense to water in the asphalt and later cause foaming.

Slight foaming can be overcome by stirring asphalt through the dome vigorously with a paddle. This breaks up the bubbles and will oftentimes make it possible to unload a car which is inclined to foam.

Before raising the valve and attempting to unload the asphalt from the car, the contents should be carefully examined with a rod or pole from top to bottom to determine if the asphalt in the bottom of the car is completely liquefied. The first asphalt to melt rises to the top of the car, the unmelted portion continually settling down upon the coils and gradually taking on a heavy "liverlike" consistency until the entire contents of the car completely liquefies.

The connecting line for pumping out should never be less than four inches, and where necessary bushed to the outlet connection.

Coils should always be blown out with air in freezing weather every time the steam is turned off for any length of time, in order to prevent condensed water freezing and bursting them.

If the unloading line is not steam-jacketed, a small fire under it will prevent the first asphalt from cooling in the line. Such fires should not come in contact with the car.

Table for Converting Cubic Yard Weight to Tons

In view of the fact that all shipments and most purchases of coarse and fine aggregate are based on the ton weight, the following conversion table, worked up by Mr. Theo. A. Polansky, C. E. Parkersburg, W. Va., should prove of general service:

TABLE SHOWING CUBIC YARD WEIGHTS IN POUNDS IN TON WEIGHT EQUIVALENTS.

Weight of aggregates in pounds per cubic yard.	Equivalent weight in tons.	Fractional number of cubic yards per ton.
2,100	1.050	0.952
2.150	1,075	0.930
2,200	1.100	0.909
2,250	1.125	0.888
2,300	1.150	0.869
2,350	1.175	0.851
2,400	1.200	0.833
2,450	1 225	0.816
2,500	1.250	0.800
2,550	1.275	0.784
2,600	1.300	0.769
2,650	1.325	0.754
2,700	1.350	0.740
2,750	1.375	0.727
2,800	1.400	0.714
2,850	1.425	0.701
2,900	1.450	0.689
2,950	1.475	0.677
3,000	1.500	0.666
3,050	1 525	0.655
3,100	1.550	0.645
3.150	1.575	0.635
3,200	1.600	0.625
3,250	1.625	0.615
3.300	1.650	0.606

Suggestions for Contractors on Concrete Road Construction

Useful suggestions on concrete road building, compiled from long observation and practice in this kind of work, are given by Mr. Clyde E. Learned, Highway Engineer of the U. S. Bureau of Public Roads, in Public Roads, the official publication of the Bureau. The suggestions follow:

Never attempt to build a concrete pavement unless you already have built one or have in your organization at least one good foreman thoroughly acquainted with this type of construction.

Troublesome equipment, especially the principal items such as the mixer and the pump, often will cause delays that are more costly than interest on new equipment. Therefore, in all cases where used equipment is employed, it is advisable to see that all is thoroughly overhauled and put into good running order before starting work. If the job is a large one, especially if isolated from repair shops, it usually will pay to consider carefully the purchase of new mixer and pump.

The cables on the mixer, as well as various parts on the mixer, the pumps, and other machines, are subject to rapid wear. To avoid delays caused by the breakage of such parts, spares should be kept on hand or under order at all times.

Have on hand at all times a list of repair parts and the nearest agencies for each machine.

Careful Overhauling of Equipment Saves Money.—Keep all nuts on the mixer tightened and use plenty of oil and grease. It is money well spent to have the machinist spend ample time in carefully overhauling, cleaning, and adjusting all machines on the job.

Use a well-laid loop in feeding the mixer. By laying a 3 by 6 ft platform in front of the skip and by properly placing the runways a large skip can be loaded in a surprisingly short time.

In soft ground it will be necessary to provide runways for the wheelbarrow men and for the mixer itself. In fact, it is always better to have runways, but where they are used ample room should be provided at the skip for turning and there should be no drops onto or off of the runways.

Have the material that is distributed on the road ahead of the mixer properly placed as considerable delay is caused when wheelbarrow men have to wheel materials a long distance.

Place a reliable man in charge of receiving and placing materials and do not depend upon the teamsters or the truck drivers to allocate them properly. Dump wagons and trucks often cut up the subgrade, with the result that more or less material may be lost in the ruts. This loss can be largely eliminated by having a laborer fill any ruts where a load is to be dumped.

Take Care of the Subgrade.—Many contractors do not pay enough attention to the preparation of the subgrade or to taking care of it after it has once been shaped up, with the result that they have costly delays at the mixer and much unnecessary expense in reshaping the subgrade. If enough care is exercised in these particulars it usually is possible to eliminate the one or two men working on the grade ahead of the mixer.

Figure the proper spacing of the loads before cement is piled along the road ahead of the mixer.

Have the cement dumped on the opposite side of the road from the pipe line.

Shake out and tie up cement sacks as they are used. A man will shake enough cement out of the bags to more than pay his wages.

Have the sacks gathered up every night rather than left in piles along the road.

Have boards placed under any cement that is to be left out over night and have enough canvas on hand to cover it in case of rain.

If side forms are to be used, grade the road so that the shoulders will not interfere with placing them.

Where wooden side forms are to be used over and over it will save money to cap them with angle irons.

If motor trucks are used for hauling, it generally will be advisable for them to back in to dump their loads.

Economy in Use of Trucks.—For hauling the materials for a concrete road it is more economical to use trucks with a capacity of from 3½ to 5 tons than trucks of a smaller capacity unless local soil conditions make the operation of such large trucks inadvisable.

A small-capacity truck often proves economical for hauling cement, as it can be driven between the material piles on the road and has comparatively little tendency to damage the subgrade.

Before buying a pump do a little figuring, taking into consideration the size, length, and condition of the pipe line to be used, the maximum vertical height to which water is to be raised, the amount of water that will be required, and the source from which it must be obtained. When the supply is from a deep bored well it will be necessary to provide an extra pump for lifting the water from the well. This should be a deep-well pump connected to an appropriate engine. It is used to pump the water into the storage tank or reservoir from which the high-pressure pump draws the water for the mixer.

Do not use less than a 2-in. pipe line, and discard all defective lengths and rethread all poor ends before laying it.

Water Requirements.—The water requirements will vary from 20 gal. to as much as 60 gal. per minute. This includes water for the concrete mixing, for wetting the subgrade, and one stream for curing the concrete. Usually one stream is not enough to keep the green concrete in good condition, so it will often be necessary to resort to night pumping to provide enough water for this purpose.

The following tables will be of assistance in determining the size of pump required for most conditions:

TABLE I.

Water required per minute.	Loss in friction head (in feet) in 2-inch pipe. 1 mile.	2 miles.	3 miles.	4 miles.
20 gal.	51	102	153	204
30 gal.	110	220	330	440
40 gal.	194	388	582	776
50 gal.	296	592	888	1,184
60 gal.	468	936	1,404	1,872

To the loss in head in the above table it will be necessary to add the vertical height that the water is to be pumped and to make allowance for angles and valves.

The theoretical horsepower required to raise water to different heights is given in the following table:

TABLE II.

Per miute.	Height to be raised (in feet). 100	200	300	400	500	600
20 gal.	0.50	1.00	1.50	2.00	2.50	3.00
30 gal.	.75	1.50	2.25	3.00	3.75	4.50
40 gal.	1.00	2.00	3.00	4.00	5.00	6.00
50 gal.	1.25	2.50	3.75	5.00	6.25	7.50
60 gal.	1.50	3.00	4.50	6.00	7.50	9.00

Multiply theoretical horsepower by 4 for deliveries of 30 gal. per minute or less and by 3 for deliveries of from 30 to 125 gal. per minute.

EXAMPLE.

Required, 40 gal. per minute; maximum distance to be pumped = 2 miles, up a hill 100 ft. in height.

From Table I:
Loss in head in pipe line.............................= 388 ft.
Vertical height up hill...............................= 100 ft.
Estimated loss of head in valves, elbows, etc........= 20 ft.

Total head ....= 508 ft.
From Table II:
Theoretical horsepower required......................= 5 HP.
Actual horsepower required for engine and pump,
three times theoretical horsepower...................= 15 HP.

Relief Valves to Prevent Damage.—The vertical distance from the water surface to the pump should not exceed 20 feet, and a foot valve should be placed on the end of the suction pipe. To prevent damage from excessive pressure in the line all pumps should be provided with relief valves.

Provide a 1-inch hose from pipe line to mixer.

At the pump provide a check valve in the main pipe line, and between it and the pump put in a tee with a short nipple, on which a globe valve is set. Open the globe valve before starting the pump, allowing the water to discharge into the air at this point. Close the valve as the engine gets up speed.

Globe valves should be provided in the pipe line about every 1,000 feet apart, 2-inch to 1-inch tees from 200 to 300 feet apart, and unions about 500 feet apart.

The insert for the mixer should be made up as follows: A 1-inch short nipple, a 1-inch globe valve, and another 1-inch short nipple, to which the mixer hose is coupled.

The hose for wetting down the concrete usually is 1-inch size, as it is easy to drag around. The inserts are made by using a 1-inch nipple, then a 1-inch square-head cock, and then another 1-inch short nipple. About a dozen of these inserts should be provided, and they should be moved from place to place as the progress of the work requires.

Pipe Line.—In laying the pipe line eliminate sharp sags and raises as much as possible, for air pockets at the high points will cause much trouble. If an extra tee is placed at each high point, a nipple inserted and a valve attached, the air pockets can be blown off readily. Provide a similar outlet at all low spots in order that the pipe may be drained if occasion requires.

Two men can lay 1,500 to 2,000 feet of good pipe a day.

If the size of the job warrants it a blacksmith shop will save considerable time. Provide it with a blacksmith's outfit, a strong bench vise, a drill press, and a supply of various sizes of round and flat iron.

Use white lead or a mixture of graphite and machine oil for connecting pipe line. Machine oil is preferable if the pipe is to be taken apart frequently.

When a split or a leak occurs in the pipe line mark it with red lead, so that it will be noticed, and cut out the defective section before laying the pipe again.

Provide a good grade of 1-in. hose for general use on the work

Tools and Supplies for Repair Work.—The following list of tools and supplies are recommended for repair work on the concrete mixer and pipe line:

Hinge pipe vise and bench (light and movable).
Pipe cutter, pipe dies, and holder.
Breast drill, with assortment of bits.
Cold cutters, cold chisels, and hacksaws.
Wrenches—monkey, Stillson, Westcotts, open-end, etc.
Hose menders and couplings.
Pliers and end-cutting nippers.
Rubber packing, electric tape, and candle wicking.
Assortment of carriage and machine bolts.
Extra supply of valves, tees, ells, unions, couplings, nipples, plugs, and reducers.
Rolls of 18-gauge wire for bundling cement sacks.

Proposed Specifications for Block for Granite Block Pavement

At the last annual meeting of the American Society for Testing Materials, the Committee on Road Materials, of which Mr. A. H. Blanchard is chairman, submitted the following tentative specification for granite paving blocks:

The blocks shall be of granite of medium-size grain, showing an even distribution of constituent minerals. They shall be of uniform quality and texture throughout, and free from seams or disintegrated materials.

Physical Properties and Tests.—The average of three tests on sample blocks shall conform to the following requirements as to physical properties:

FOR HEAVY TRAFFIC.

French coefficient of wear..........not less than 11
Toughness ....not less than 9

FOR MODERATELY HEAVY TRAFFIC.

French coefficient of wear ....not less than 8
Toughness ....not less than 7

The French coefficient of wear shall be determined in accordance with the Standard Test for Abrasion of Road Material (D 2) of the American Society for Testing Materials.[1]

The toughness shall be determined in accordance with the Standard Test for Toughness of Rock (D 3) of the American Society for Testing Materials.[2]

Dimensions.—The blocks shall conform to the following requirements as to dimensions:

Length on top, in........................ 8 to 12
Width on top, in......................... 3½ to 4½
Depth, in. .... 4¾ to 5¼

Dressing.—The blocks shall be so dressed that the faces will be approximately rectangular in shape, and the ends and sides sufficiently smooth to permit the blocks to be laid with joints not exceeding ½ in. in width at the top, and for 1 in. downward therefrom, and not exceeding 1 in. in width at any other part of the joint.

The wearing surface of the blocks shall show no depressions more than ⅜ in. deep, and the edges and corners shall be unchipped and unbroken.

Inspection.—At least six blocks shall be selected for physical tests by the engineer or his authorized representative, subsequent to delivery at the place of use, so as to fairly represent actual deliveries. No sample shall include blocks that would be rejected by a visual examination. The bedding plane shall be marked on at least two of the blocks selected.

All deliveries shall be subjected to further inspection at the place of use, prior to and during laying. All blocks which fail to conform to the requirements of Sections 1, 5 and 6 shall be rejected.

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[1] 1918 Book of A. S. T. M. Standards, p. 623.
[2] Ibid., p. 625.

Standard Details of New Jersey State Highway Department for Minor Features of State Roads

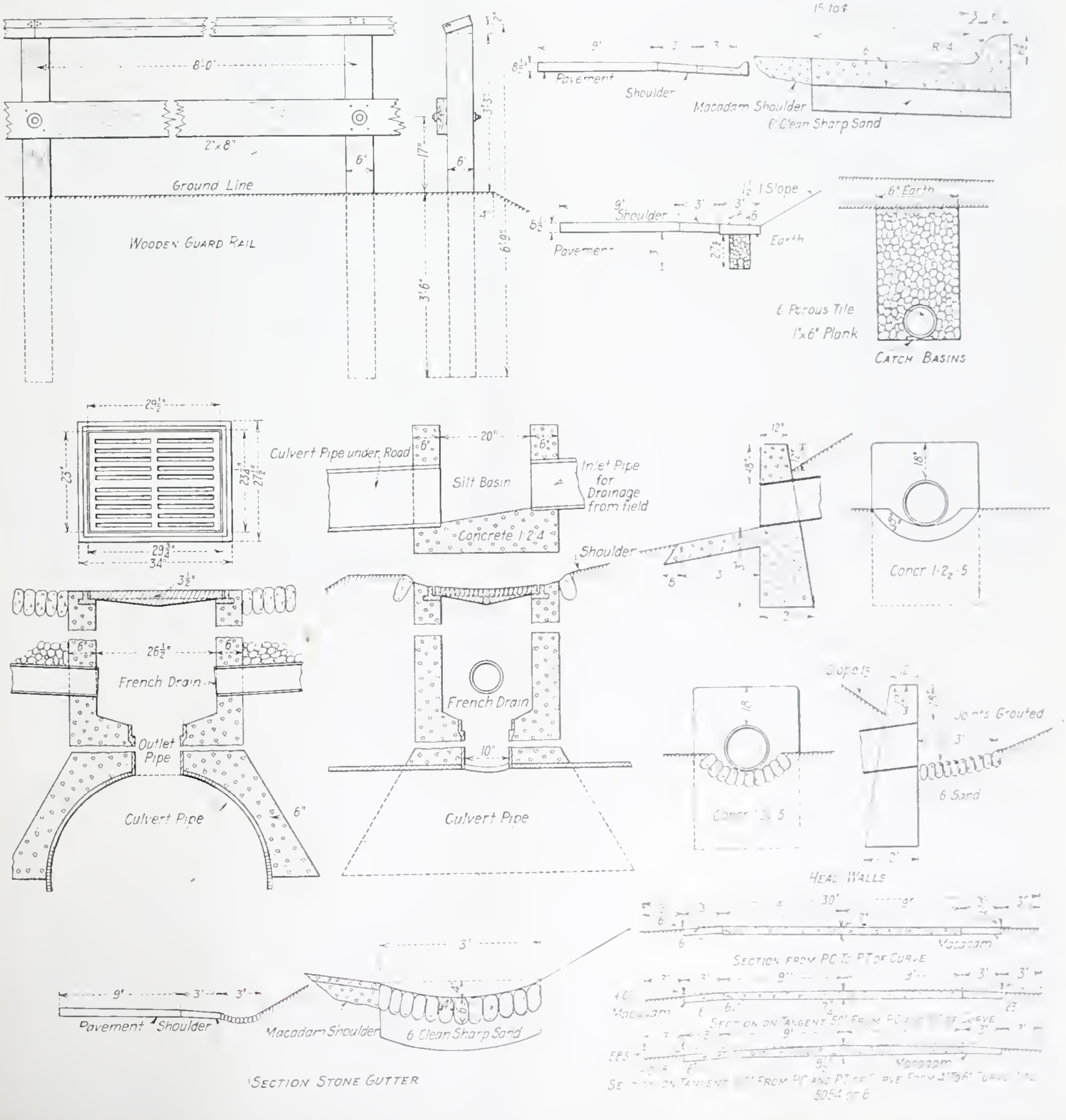
Construction details for the smaller items entering into the roads constructed by the State Highway Department of New Jersey are illustrated below. The upper right hand drawing shows the standard concrete gutter. The joints for this are to be of the premoulded bituminous composition type and are to be placed every 10 ft. When the gutter is constructed over a French drain 2 in. of gravel is used instead of the 6 in. sand foundation shown in the cut.

The next illustration shows the standard French drain. A 6 in. porous tile is used on all French drains except where V. T. standard sewer pipe is called for on the plans. The cross drain construction is a 6 in. porous tile into 8 or 10 in. vitrified "Y's." Salt hay is placed between the stone and subgrade. The filling over the tile may be 2½ in. slag or approved broken stone. The standard methods of banking on curves are shown in the lower right hand drawing.

The standard wooden guard rail is made of 6 in. x 6 in. cedar, locust, oak or chestnut posts, surfaced on four sides, 2 in. x 8 in. oak or chestnut rails and 2 in. x 6 in. caps. The rails break joint alternately on center of posts. Side rails are fastened with 60-D spikes and [illegible] bolts. Bolts have button heads and cast ogee washers on face of fence, and flat washers and square nuts on back of posts.

The lower 4 ft. of posts are treated with coal tar preservatives. All joints are painted with two coats of white lead and oil paint before being assembled. Exposed portion of fence is painted with two coats white lead and oil after erection.

In the drawings of the standard details for catch basins and culvert pipes the illustration at the right shows the typical construction where the culvert is less than 3½ ft. below the grade of the gutter. The other drawing shows the construction when the culvert is over 3½ ft. below gutter grade.



Construction Details of New Jersey State Highway Department.

Maintenance of Earth, Gravel and Macadam Roads*

By CAPT. J. A. DUCHASTEL,
City Manager, Outremont, Quebec.

Misconception Regarding Permanent Roads.—There are many people who believe that once a road has been built it is down forever, especially if it has been constructed of the so-called "permanent" type, but this is quite incorrect. Road maintenance should begin the day and moment the road has been completed. I do not mean by this that large sums should be spent for maintenance on new roads, but some thorough inspection and superintendence should then be started and kept up.

Too many people misunderstand the meaning of the word "permanent" applied to road construction. The dictionary definition of this word is too often taken literally. The word "permanent" is derived from the latin "permanens," from "per" (through) and "manere" (remain), that is to say "remain for ever." It has been the custom to use this word "permanent" when a more durable type of road construction has been advocated, and many road enthusiasts have misused this term.

Another erroneous conception people have about the permanency of a road is due to the fact that they have ideas about the roads built by the Romans and, according to what they have been told, are still in use today. It is quite true that some Roman roads are still in existence and used even today, but the wearing surface has been replaced time and time again.

I know only two permanent features of a road and they are:

1. Its location.
2. The heavy grading work which was done at the early stages of its construction.

All other details of road construction, including bridges and culverts, are more or less of a temporary nature.

The road surface, or better, the wearing surface of a road has only a limited life, and the sooner the public is accustomed to realize this fact the better it will be. The life of a road surface depends upon the nature of the materials used in its construction and also upon the nature and volume of the traffic traveling over it.

The surface of a roadway should be selected with respect to the traffic the road is liable to have after the improvements have been completed. It is sometimes very hard to determine in advance density of the future traffic. Improved roads will attract an ever increasing traffic, but a fairly close estimation can be arrived at after a little study.

General Principles of Roads.—The majority of the roads in this province are of the non-permanent type, and my intention is only to talk upon the maintenance of the earth roads, the gravel roads, and the macadam roads.

There are a few general principles common to all roads that I would like to bring out here.

A bad road wears out much faster than a good road, and consequently the cost of maintenance is greatly increased if the road has been neglected for any length of time.

Two types of wear to roads are known:

The Surface Wear.—This wear is caused by the direct contact of the wheels passing over the road, and by the hoofs of horses, and also by the deteriorating action of the elements, such as wind, rain, etc.

The Internal Wear.—This wear is caused by too heavy loads and frost action. The materials with which the road is constructed are disturbed from their position and a general disintegration sets in.

Maintenance of Earth Roads.—I wish to submit a few suggestions in connection with the maintenance of earth roads. It must be remembered that the great majority of roads in this province are of this type.

1. When the surface of an earth road is very rough it is advisable to harrow it with a spike-tooth-harrow, so as to facilitate the dragging. It is preferable that this harrowing be made in the spring when the road surface is still impregnated with water.
2. All the ruts and depressions of the road surface must be filled with material of same nature of the road surface itself.
3. It is important that no sod or vegetable matter of any kind be used to fill the ruts or depressions of the road.
4. In reshaping the road surface use a road drag, and make sure that all the ruts and depressions have been thoroughly filled.
5. In dragging a road it is important that the dragging be started from the sides of the road working towards the center.
6. No ridges should be left on any portion of the road after the dragging has been completed.
7. The best time of the year to do this work is early in the springtime and, if necessary, after a heavy rain.
8. It is necessary to remove all foreign substances that might have been brought up to the surface of the road by dragging.
9. It is also very important that the culverts be thoroughly cleaned, and that their outlets be left in good order. The ditches must be cleaned and enlarged if necessary, so as to improve the drainage.

The cost of maintaining this type of road varies from $50 to $100 per mile per year, according to the width of the road.

Maintenance of Gravel Roads.—The suggestions made in connection with the earth roads can be applied to the gravel roads if they have not been superficially treated with bituminous material.

The cost of maintaining this type of road varies from $15 to $50 per mile per year. This price is exclusive of the cost of the cutting of weeds, etc.

Maintenance of Macadam Roads.—Modern traffic, composed of steel tire vehicular traffic and automobile and heavy truck traffic, has been the cause of many failures of highways that were considered of first class construction up to recent years. The steel tire grinds and pulverizes the road metal, and the automobile traffic sweeps the dust, thus produced, away. To prevent this surface wear it has been necessary to find some material that will set as a sort of preservative to the road surface. After numerous experiments road builders have found that the methods of oiling the roads produced a carpet coat giving good results.

The bituminous carpet is laid on the road with the idea of protecting it from wear from traffic and climatic conditions. It renders the road impervious and lengthens the life of the road considerably.

To be effective, the carpet coat must be laid according to the following rules:

All dust must be thoroughly removed from the road surface with brooms so as to permit an intimate adhesion between the road carpet and the road surface. For economy sake it is advisable that a rotary horse sweeper be used. All the small depressions of the roadway in which dust might lodge should again be swept by hand brooms. The road surface should resemble a mosaic after the sweeping is done, and all stones should be exposed over the entire area.

The liquid bitumen should be applied after heating, and in moderate quantities. The quantity applied per square yard will vary from ⅕ to ⅓ Imp. gal., depending upon the conditions of the road surface. All surplus bitumen will be swept with hand brooms over the road so as to avoid the formation of puddles, otherwise the carpet would be of unequal thickness and creeping of the road surface would soon take place.

A couple of hours after the application of the bitumen, the surface should be covered with sufficient coarse sand or screenings to absorb all the bitumen.

No road oiling should be undertaken unless the roadway is absolutely dry, otherwise any dampness at the surface of the roadway might prevent the adhesion of the carpet. Unless perfect adhesion is obtained the carpet is apt to break away in slabs during the cold weather.

It is important that the heating of the bitumen shall be constantly observed and the use of thermometers, is recommended. Care should be taken that the flash point of the road oil be not exceeded.

In the case of bleeding of finished surface an application of coarse sand or screenings should be made without delay. I have had some experience myself in road oiling and am pleased to state that the results obtained are far beyond my expectations. I find that the roadways that I have treated with road oils have been cheaper to maintain from year to year. They are easier to clean; they are dustless and mudless.

Cost of Road Repairs and Oiling at Outremont.—I give a few figures showing the annual cost of repairs to roadways in Outremont for the past 9 years, and also the cost of oiling these roadways. It will be noticed that the cost per square yard for the repairs has decreased from 1910 to 1918 at the rate of 50 per cent, and this is in the face of the fact that the wages and material have increased 83 per cent.

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*From a paper presented May 20 at the Sixth Canadian Good Roads Congress.

CITY OF OUTREMONT COST OF STREET REPAIRS.
(Permanent pavements not included.)

Year.	Total cost.	Sq. yd.	Cost per sq. yd., ct.	Average price of labor
1910	$ 8,866	124,945	7.1	$1.50
1911	10,557	157,595	6.7	1.75
1912	14,412	208,419	6.9	1.75
1913	11,773	244,474	4.8	1.75
1914	15,165	273,014	5.6	1.75
1915	18,928	309,754	6.2	1.75
1916	11,314	302,784	3.7	2.00
1917	12,817	322,684	4.0	2.50
1918	11,824	355,624	3.3	2.75

COST OF STREET OILING

Year.	Total cost.	Sq. yd.	Cost per sq. yd., ct.	Average price of labor.
1914	$ 787	3,000	2.6	$1.75
1915	2,624	101,930	2.6	1.75
1916	5,037	187,675	2.7	1.75
1917	6,331	184,540	3.4	2.50
1918	6,202	138,690	4.5	2.75

Better Salaries Needed to Retain Highway Engineers in Public Service

Up to 27 years ago road building was merely the avocation of farmers, which they followed for a few days during the summer. In 1892 the first steps were taken toward changing this farmers' avocation to a profession. Before 1892 there were practically no engineers used in country road construction, and there was no idea in the general public consciousness that it would be profitable to employ them for this purpose. Expenditures for roads have grown from hundreds of thousands to hundreds of millions per year. With this growth there has gradually grown up a conviction that road building is too important to leave entirely to men who only work at it for a few days a year, and now the real opportunity for the trained highway engineer is at hand. While there is still in existence a feeling in the minds of some, who unfortunately usually arrogate to themselves the title of "taxpayers" (and usualy pay little tax), that a public office is a private snap and that anyone who is ambitious to fill the job is satisfactory, regardless of his lack of ability or the waste of public money which his inefficiency may cause, there is on the other hand, fortunately, a rapidly growing appreciation that it is good business for the public to pay for brains and ability in public service—that poor pay results in poor work and is a costly investment. Private business is much more keenly appreciative of these facts than the public and the opportunities and good salaries that are necessary to attract the best engineering and executive brains are quite likely to come from contractors and material companies. The salaries paid today to the men who sell the machinery and road materials that we use are much higher than are paid for equal ability in county and state highway service. The engineer who can devise a system of constructing concrete roads at ordinary prices at the rate of a mile a week can get $10,000 a year from a contractor, because he will increase his profits to justify that and much more. The engineer who can invent a concrete road building outfit that will cut the cost 10 per cent is likewise sure of a highly paid job, because the contractor's profits will be increased to warrant it. I believe these things can be and will be done. The size of the contracts that will be let is so great that contractors are going to be very anxious to get men with the training and ability to do this, and there is room for a large number of them. The effect of this saving will be to draw our best men from public employment unless the public is wise enough to provide funds to pay these men sufficient to keep them in public service. Most of the county boards increased the pays of their county commissioners this last November in recognition of this fact. I consider this one of the most hopeful signs I know of pointing toward the efficient spending of our highway funds. There isn't a county in the state that can afford to pay less than $2,500 a year, if they can get the right sort of a man. The salaries needed to draw the best brains available into highway work are insignificant compared to the waste of money that will result if these brains are not drawn into highway work.—W. O Hotchkiss, Secretary Wisconsin Highway Commission, in an address before the Annual Road School of the Commission.

Stresses in Concrete Road Slabs from Wheels of Heavy Trucks

At the present time it is imposible to calculate the proper thickness of a concrete road slab with much certainty. It is known that a thicker slab is required where the subgrade is soft than where it offers a good bearing, and that heavy loads require a thicker supporting slab than light loads; how much thicker, however, has not been determined. The stress in a slab depends upon the bending moment produced in the slab, and this in turn is dependent largely upon the distribution of pressure over the subgrade. It is recognized that ununiform subgrade pressures are due to causes other than the heavy traffic loads carried by the slabs. An investigation to discover how the road slab is stressed directly under the wheels of heavy trucks and to determine whether this stress is apt to be a governing influence in the designs of the slab, has been initiated by the U. S. Office Bureau of Public Roads. This test is one of a series of investigations outlined to include an adequate range of the different varieties of subgrades and slab thicknesses. The test was made on the concrete road between Camp Humphreys and Alexandria, Va. The road surfacing at this point is 18 ft. wide, 8 in. thick at the center, and 6 in. at the sides. A 1:1½:3 gravel concrete was used, having a crushing strength, as determined by 6 by 12 in. cylinders cast in the field at the time the road was laid, of 3,190 lb. per square inch. The aggregates in the concrete at this point were Potomac River sand and gravel. Here the road runs through a 6-ft. cut and the subgrade in the past has remained rather wet and soft. The soil is composed of a sticky clay, which, when wet, has very low bearing value.

To measure the pressure distribution, four pressure cells were designed in the Bureau of Public Roads. In order to determine the distribution of pressures under heavy wheel concentrations, a class B standard army truck was loaded with 5 tons of sand. The front wheels and rear wheel of the loaded truck were weighed separately and the axle loads were found to be 5,000 lbs. and 17,000 lbs., respectively.

On Feb. 5, 1919, a test was made on the Camp Humphreys road with this loaded truck. It was backed 1 ft. at a time up to the central measuring cells. When the rear wheels reached a position directly over the cells, the truck was backed 1 ft. at a time still farther until the front wheels were just over the cells. As a second test the truck was backed with the wheels as close to the side of the road as possible so that they would be made to come directly over the cell placed at the extreme side of the road. During the progress of the preliminary measurements, taken over a period of four months, opportunities offered themselves for obtaining some idea of the effect of light loads on the subgrade pressures and these are presented in the following table:

		Ford	Boiler	Front Army truck.	Rear Army truck
Load on slab	[1]200	[1]1,350	[1]3,680	[1]2,500	[1]8,500
Maximum intensity of pressure	[2]0.2	[2]0.4	[2]3.5	[2]4	[2]6.7
Radius of area of distribution		[3]2	[3]3½	[3]3	[3]6

[1]Pounds. [2]Pounds per square inch. [3]Feet

The results of the investigation are given by Mr. A. T. Goldbeck, Engineer of Tests, U. S. Bureau of Roads, in a report made public recently by the Bureau. The tentative conclusions drawn from this preliminary investigation are as follows:

1. That a concrete road slab under the action of traffic or perhaps under the influence of frost and different percentages of moisture in the subgrade is continually bending, so that the reaction pressures between the subgrade and slab are neither constant nor uniform in intensity.

2. The reaction pressures due to heavy wheel loads are a maximum directly under the loads and vanish to zero in a comparatively small radius, which partially depends upon the intensity of the load. A heavy wheel load is distributed over a larger radius than a light wheel load. For this particular subgrade, a load of 8,500 lbs. has a radius of distribution of pressure of about 6 ft., most of the pressure, however, being exerted over a radius of about 4 ft.

3. As the concrete slab recovers from its deflection after the passage of a load more readily than the soft subgrade, there is a tendency for the continual deflection of the slab to produce areas having very little or no bearing. If the traffic is concentrated at the center of the road, as it is on many concrete roads, the continual deflection tends to de-

press a soft subgrade away from the center of the slab, which would then be more largely supported at its sides. In extreme instances this might account for some longitudinal cracking in concrete roads.

4. As nearly as can be estimated from the results of this test, the tensile stress in an 8-in. concrete slab directly under an 8,500 lb. wheel load at rest on the road is only 34 lbs. per square inch when the slab is well supported on the subgrade As the modulus of rupture of 1:1½:3 concrete is about 600 lbs. per square inch, it is seen that this pavement should be able to withstand considerable impact before cracking. Should the concrete arch, over very soft spots, so that there is no support directly under the load, the tensile stress may become very high. Such a condition arises when the sides of the slab are raised by frost action or possibly when the subgrade is worked any from under the slab by continual deflection.

5. It is probable that the tensile stres which results in the slab directly under heavy wheel loads is never very great as long as the slab rests on the subgrade and it is unlikely that the slab design would ever be controlled by this stress.

State "Reward" Township Roads in Pennsylvania.—The governor of Pennsylvania has signed the bill providing for a system of state "rewards" to townships for the construction and improvement of township roads, and for the erection and construction of township bridges, in townships of the second class. An appropriation of $1,000,000 will be available beginning Dec. 1, 1919. The new law takes the place of the one which provided for bonuses of 50 per cent of the amount expended by townships for road work, not exceeding $20 per mile. By the terms of the new law the State Highway Department will pay rewards when work by the township has been completed and inspected. Rewards will be granted by the Commonwealth for improvements of the following nature: Grading and draining a section of road not less than ½ mile long; graveling or cindering a graded and drained road not less than ½ mile in length; for macadamizing a road or for constructing a Telford macadam road not less than ½ a mile long; for constructing a concrete, brick or bituminous surfaced road of not less than a ½ mile in length; for the erection and construction of bridges 3 ft. or more span, constructed of concrete or stone or a combination of concrete and stone, or a steel bridge with a floor constructed of materials approved by the State Highway Department, and for the purchase and installation of culvert and drain pipe. The rewards are to equal 33⅓ per cent of the cost of the proposed improvements, not to exceed certain sums. All of these rewards will be based on roads the improvement for which is to be a width not less than 16 ft.; and a corresponding reduction or addition in the amount of the reward will be made as the width of the improved road is increased or reduced; but no reward shall be made for the improvement of any road less than 12 ft. wide.

Tractor Has Advantages Over Horses for Alaska Road Work.—Tractors have given good results in the construction and maintenance of military and post roads in Alaska, according to the last annual report of the Board of Road Commissioners for Alaska. The report states that, in June, 1918, two 12-25 hp. tractors of the wheel type were shipped to Fairbanks, where they are being given a thorough test on a 100 mile section, with very satisfactory and economical results. At present each tractor is doing the work of eight horses, at a daily operating cost about equal to the cost of feeding three horses.

"It is apparent," continues the report, "that in Alaska the tractor has numerous advantages over horses, which must be fed throughout the year, although the working season is never more than five months in length. During part of the winter the horses are used to haul and distribute supplies for the next season's work, but the cost is extremely high, due to high wages and cost of boarding teamsters, the large amount of forage consumed by the horses while doing the work, the time lost through extremely cold weather, etc. While it will be necessary to do a certain amount of this winter freighting for some time to come, a tractor will be used experimentally this fall to test its desirability for freighting during the open season."

Recomended Practice of Mississippi Valley State Highway Departments for Concrete Road Construction*

Proportions.—One-course road: The concrete for a one-course pavement that is to be machine finished should be mixed in the following proportions: 1 sack of cement, 2 cu. ft. of sand and 4 cu. ft. of coarse aggregate. For work that is to be hand finished the proportions should be 1 sack of cement, 2 cu. ft. of fine aggregate and 3½ cu. ft. of coarse aggregate.

Two-course road: The proportions of the concrete for a two-course pavement should be as follows: For the lower course, 1 sack of cement, 2 cu. ft. of fine aggregate and 4 cu. ft. of coarse aggregate.

The proportions for the wearing course should be 1 sack of cement, 2 cu. ft. of fine aggregate and 3½ cu. ft. of the coarse aggregate prescribed for the wearing course of the two-course pavements.

Quantity of water: It is recommended that extreme care be employed in proportioning the mixture as regards water content, and that this fact be checked by the slump test as follows: For the test, 6 by 12 in. cylinders should be tamped full of the concrete as mixed and the cylinder immediately removed. For work that is to be finished by hand, the slump of the concrete upon removing the cylinder should not exceed 6 in. and for work that is to be machine finished the slump should not exceed 2 in.

Thickness.—The thickness should be not less than 7 in. at the sides nor 8 in. at the center for two-track roads up to 20 ft. in width. The thickness for single-track roads should be not less than 7 in. at any point.

Widths.—It is inadvisable to build concrete roads less than 18 ft. in width. Where a single-track road must be built it should be made 9 ft. in width and the 9 ft. should be centered on the center line. Pavements with widths between 10 ft. and 16 ft. should not be built.

The width of grade to be traveled should be not less than 24 ft. for any width of pavement and the minimum over-all width of shoulders should be at least 8 ft. more than the pavement width.

Crown.—The crown should be a total of 1 in. for two-track roads not exceeding 20 ft. in width. If on center line the crown for single-track roads should be ½ in. If placed with one edge on the center line the surface should be sloped all one way with a total slope of 1 in.

Alignment.—No radius should be less than 200 ft. on center line of turns.

Widening Turns.—On all turns the center line of the road should be marked by a white strip 8 in. wide.

Superelevation of Curves.—Except when drainage condition may prevent, the grade of the original center line before widening is to be maintained where pavement is superelevated. The crown of the surface is to be flat where pavement is superelevated.

Grades.—Concrete pavements can be successfully constructed on any maximum grade likely to prove best from general economic consideration. In the middle west maximum grades exceeding 6 to 8 per cent should not be adopted under ordinary circumstances.

Considering the permanency of concrete surfacing a greater expenditure of money is justified in eliminating frequent and minor breaks or changes in grade than is the case with a less permanent type of road.

Vertical curves on steep grades should be sufficiently long to give an unobstructed view of at least 250 ft.

Subgrade.—It is recommended that, if possible the subgrade for a concrete pavement be not trenched out and that it be kept higher than the berms, so as to provide drainage directly to the side ditches.

Very careful attention should be given to the rolling of the subgrade. It is recommended that a macadam type of roller be used, weighing not less than 10 tons. If the rolling at any time causes the subgrade to become wavy, the rolling should be stopped immediately over the wavy parts, and the soft material investigated. In clays this is almost always due to moisture and unless it is possible for it to dry out by the sun and wind without delaying the work, it should be removed and replaced with dry clay or other suitable material that can be rolled in a sitsfactory manner. If any depressions develop they should be filled with acceptable material as the rolling progresses. Sand and sandy soils require a minimum amount of rolling.

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*From the report of the conference of the Mississippi Valley Association of State Highway Departments, held last February at Chicago to consider questions relating to rural concrete road construction.

It is recommended that the rough grading be completed very closely to the intended cross section of the subgrade and to the full width of the shoulders. Avoid shallow filling without plowing. Avoid filling narrow, deep ruts without plowing and disking The finished subgrade immediately ahead of the concrete should be corrected to proper cross section, using a template.

Where the method of depositing the aggregates on the subgrade is followed, the subgrade should be completed fully in sections not exceeding 600 ft. in length immediately before the aggregates are deposited. The surface should be brought to true cross section, using a template or other acceptable method. The roller should be kept in constant operation while the aggregate is being delivered. Any ruts or irregularities caused by the handling of the aggregates should be filled up and thoroughly tamped. Wherever possible, hauling over finished subgrade with teams or motor trucks should be avoided.

Where necessary, to avoid formation of an objectionable layer of dust, the subgrade should be sprinkled in advance of placing materials.

Mixer.—The mixer should be of a standard paving type having a capacity of at least 2-bag batch, commonly known as size No. 14.

The mixer should be equipped with a boom and bucket or some other mechanical device that will deliver concrete of a proper consistency, also with an automatic timing device and a device that will accurately measure the water for each batch.

Water Supply.—In addition to the general recommendation of the American Concrete Institute recommended practice, the water supply should be free from injurious substances, duplicate pumping machinery should be provided, booster pumps should be provided on long pipe lines, and in all pipe lines there should be provided unions at intervals not greater than 1,000 ft. Tees for supply water to the mixer and for sprinkling should be placed at intervals not greater than 100 ft.

Time of Mixing.—Materials should be mixed at least one minute after the entire batch is in the drum. The speed of the drum should be not less than 12 revolutions per minute.

Side Forms.—Steel side forms should be used and after the forms are set the joints should be inspected carefully, using a straight edge to insure proper horizontal and vertical alignment.

Placing Concrete.—The operation of depositing, spreading, and finishing the concrete should be as nearly continuous as possible for the full width and thickness of the pavement. When delays, of sufficient length to permit the concrete deposited to attain initial set, are necessary a suitable header should be placed at right angles to the road and the concrete finished to this header to true elevation and cross-section.

The concrete may be transported from the mixer to place on the subgrade in any convenient manner which avoids the segregation of materials. Any device or method of operation which tends to segregate the materials in such a manner that later operations do not completely eliminate such segregation should not be permitted.

Placing Concrete in Cold Weather.—Every effort should be made to arrange for closing concrete road work in the fall or on about such date as the Weather Bureau reports for the locality for the past 10 years indicate the probability of temperatures materially below the freezing point. If circumstances necessitate continuing work for a short period after freezing weather is likely to occur, precautions should be observed which will insure positively that the concrete may not become frozen under the most extreme conditions of temperature for the period, as indicated by weather reports for the past 10 years. Concrete should be protected absolutely from freezing by suitable means for at least 7 days after placing.

Expansion Joints.—Expansion joints should be used only in specific cases, such as junctions between the pavement and other fixed objects.

Expansion joints when used should consist of either high grade wool felt or a fibrous material combined with a coal tar or asphalt compound. The filler should contain, by weight, not more than 8 per cent of mineral matter and not less than 5 per cent nor more than 25 per cent of fiber.

Contraction Joints.—Contraction joints should not be used. Construction joints should be made at the end of each day's work or when mixing is stopped for any reason longer than one hour.

Reinforcement. For pavements up to 18 ft. in width with good foundation the value of any practicable amount of reinforcement is questionable.

For pavements over 18 ft., and especially where foundations are not thoroughly satisfactory, reinforcements, mainly in a transverse direction, may be used to advantage.

Where reinforcement is used it should be wire mesh or separate bar reinforcement, not less than 40 lb. per 100 sq. ft., and the proportion of transverse to longitudinal steel should be not less than 3 to 1.

The reinforcing should be placed not less than 2 in. from the finished surface of the pavement. Adjacent widths of the fabric should be lapped not less than 4 in. when the lap is made perpendicular to the center line of the pavement and not less than 1 ft. when the lap is parallel to the center line.

Machine Finish.—When mixtures of relatively dry consistency are used, such as those necessary to secure maximum strength as far as such strength is determined by the water content, mechanical strikers and tampers should be used. Machines should be so constructed and operated that they strike off and thoroughly tamp the concrete. They should be so constructed that they may be readily operated over the same area repeatedly. Machines to serve the purposes above indicated should be subject to the approval of the engineer. The mechanical device or devices used should be so made and operated as to leave the finished slab true to grade, crown, and surface and absolutely free from porous places.

Hand Tamping.—If a mechanical finisher is not used and the consistency of the concrete is to be as above described, after spreading the concrete should be thoroughly hand tamped by means of a tamper of the nature of a strike board operated by one or two men stationed at each end of the tamper on opposite sides of the roadway. Hand tamping should be vigorous and sufficient to consolidate the concrete in such a manner as to close all voids. The hand tamper should be followed by a final strike board and all operations carried on in such a manner as to leave the surface behind the final strike board true to grade, crown, and surface, and absolutely free from porous places.

Roller and Belt Finish.—If a medium consistency is used, the concrete should be spread, agitated, and tamped in such a manner as to insure positively the avoidance of stone pockets or porous places. It should be struck off true to grade, crown, and surface. It should then be rolled by a light hand roller of approved design operated in such a manner as to remove the surplus water and leave the surface true to grade and crown.

When hand methods of striking and tamping are used the final finishing should be executed by means of an approved belt operated in such a manner as to leave the pavement true to crown and free from waves, ridges, depressions, or other irregularities and with a uniform mat surface.

Curing.—As soon after finishing as may be possible, without marring the surface, the slab should be covered with canvas. When the concrete has set sufficiently to obviate the possibility of marring, and where local conditions permit, suitable longitudinal and transverse dikes should be built and water supplied to cover the surface of the concrete to a uniform depth of 2 in. The water should be maintained on the surface for not less than 14 days. Under conditions where it is impractical to adopt the ponding method of curing the surface of the concrete should be covered with not less than 2 in. of earth and kept moist for at least 14 days by wetting not less frequently than intervals of 12 hours.

Traffic should not be permitted to use the pavement in less than 21 days if the pavement has been subject to favorable curing conditions; nor in less than 10 days if subject to unfavorable curing conditions.

Traffic should not be permitted to use the pavement for a period of at least three days after removal of the water or earth covering.

Road Building 24 Hours Per Day

The possibilities of operating road building plant 24 hours per day are pointed out by Mr. William Ord in an interesting article in Successful Methods. The matter following is taken from the article:

Quantity Construction of Roads Possible.—Speed of construction, and consequently, greatly increased production, is influenced by many factors, such as availability of materials —which we have; efficient machinery—which can be procured; adequate labor supply—which is uncertain; and continuous operation—which is part of the answer. Granting that materials and machinery are available, the coordination of the problems of labor supply and continuous operation furnish the rest of the answer. Labor supply and operation are inseparable, and a small amount of plant calls for an increased labor supply.

With an adequate supply of labor-saving machinery, the number of men required for operation is reduced and the labor problem partly solved. Yet the rule works both ways. With plenty of both labor and machinery, by obtaining more continuous operation, such as by operating 24 hours a day, the output is greatly increased. A small plant operated continuously will produce more than the spasmodic operation of a large plant.

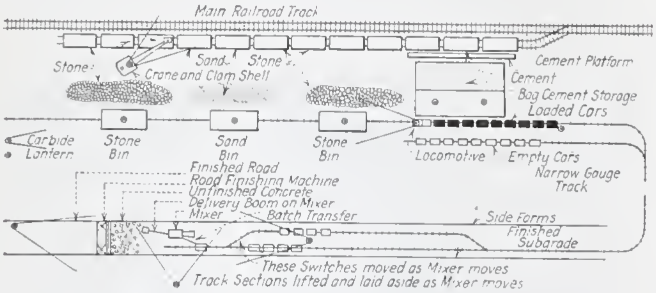

Fig. 1—Lighting for Single Mixer Job.

The length of the working season is another controlling factor in securing quantity construction. Verily, "making roads while the sun shines" is a matter of dollars and cents to the road builder. Within the glare of the night lights many miles of road may be built in the future. With a short working season, which lasts only from 5 to 8 months in some sections, the need for continuous operation is most emphatic. It has been estimated that from 20 to 24 working days a month is a good average for most highway construction jobs and this estimate makes no allowance for delays from any cause other than bad weather. Bad weather is particularly effective in causing delays in material haulage where teams or motor trucks are used.

Grading is done in the day as much in advance of the paving as circumstances will permit. But it is frequently necessary to carry on grading and paving work at the same time and it is essential that the roadway be unobstructed while grading is in progress if economical results are to be secured.

Adequate Plant Essential.—The efficient making of concrete roads leads to a division of the work in 4 operations:

1. Unloading the material (sand, stone and cement);
2. Loading and hauling the material to the mixer;
3. Mixing the concrete, and
4. Finishing the surface.

Economical management of the work involves the combination of these operations so that cars of raw material are unloaded quickly to save demurrage charges and to insure sufficient storage to make the operation of the plant independent of railroad deliveries; economical methods of reloading on the haulage equipment; rapid and uninterrupted transportation to the mixer; continuous operation of the mixer to obtain the largest possible number of square yards of completed road, for the progress of the mixer is the progress of the road; and lastly a thorough finishing to make an honest and presentable job. In all these operations the reduction to a minimum of the hand labor required is the only sure road to true economy.

Generally it will be necessary to operate the unloading plant during the night shift. This, however, is not unusual at the present time. A great many contractors are doing much of their unloading at night in order to get the most use out of their plant and in order to save demurrage on railway cars. Night unloading is also frequently necessary in the case of bunched deliveries of freight cars and shortage of material due to delayed freight shipments.

Location of Lights for Night Work.—In the typical unloading plant layout shown in Fig. 1, gravity storage bins are placed at intervals along the railroad siding with narrow gage track running under the bins past the cement shed and then to the mixer. The material is transferred from cars to bins or cars to stock piles by means of a clam shell bucket operated by a locomotive crane. Sufficient storage space in excess of bin capacity is provided to make operation independent of railroad delivery.

Materials are drawn from the gravity bins into road cars having separate and properly proportioned compartments for such materials, and a water-tight box for cement. As no cement leaves the storage shed except in the water-proof box in the road car, great economy is effected in handling it, regardless of whether the material is received in bulk or in sacks.

The layout illustrated in Fig. 2 involves the use of a tunnel arrangement instead of the bins. This method of loading cars is particularly well adapted to a large job on which two concrete mixers are operating.

The method of lighting these types of unloading plants are shown in Figs. 1 and 2. The headlight on the unloading crane should be of considerable power. This light is particularly efficient since it swings with the revolving of the crane, continuously illuminating the bucket and the material being handled.

The only lights required at the bins are lanterns, one being placed at each bin gate and another being provided as a hand lantern for the man operating the bin gate. A good tunnel man does not want a great deal of light; he prefers to work in the darkness.

The labor required for the night unloading operations is less than would be supposed. The ordinary method of handling night work is to do only those things that are absolutely necessary for laying the pavement, other work being done in the day time. While night work is generally much less efficient than day work, a considerably smaller number of men are employed.

Hauling to the Mixer Easier at Night.—The main advantage in operating trains at night instead of day time is the fact that traffic along the highways is small and consequently delays at crossings and other points where road traffic might interfere are decreased to a minimum. By hauling material in road cars instead of motor trucks or wagons, construction work delays due to wet weather do not enter into the scheme of things to any great extent. The handling and placing of concrete is not discontinued unless it is raining so hard as to damage the surface of the finished concrete. This method of transporting material, together with independence of weather conditions reduces rehandling to a minimum.

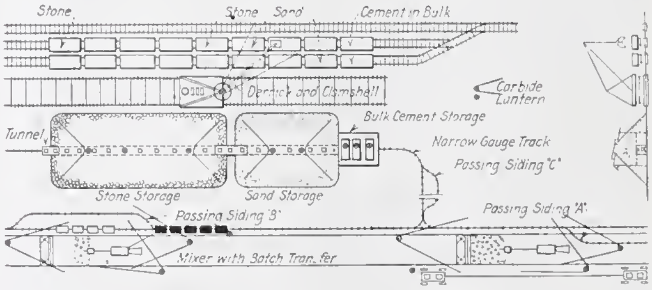

Fig. 2—Lighting for 2-Mixer Job.

The locomotive headlight and the train tail light will give sufficient illumination for night hauling. The trainmen also use hand lanterns.

Train crews should consist of two men for night operations, the same as ordinarily used in the day—that is, the locomotive engineer and one train man. No track work will be done. The size of the track crews, therefore, are increased in the day time to provide for night operations.

Mixing and Finishing at Night.—Since the progress of the mixer is the measure of the progress of the completed road, continuous operation of this unit is the key to quantity construction. All operations up to this point have been for the purpose of keeping the mixer supplied with raw material—the mixer makes the road.

The complete batch method of handling material which is illustrated in Figs. 1 and 2 may be divided into six operations:

1. Cement cover removed. Two men attach bail to car body.

2. Mixer operator lowers skip. Weight of skip raises car body from running gear.

3. Batch transfer is swung around until batch is over charging skip ready to be dumped.

4. Aggregates are dumped into charging skip.

5. Empty car body is swung back over running gear.

6. Operator raises skip to discharge batch into mixer. As skip raises, car body is lowered on running gear. Bail is detached. Cycle of operation is repeated.

For night work this method of operation offers many advantages. No material is wasted and there is no fumbling on the subgrade picking up material piled there. A uniformly proportioned concrete mixture is obtained without the cost and trouble of measuring, as all this work is accomplished at the loading station.

The number of men required at the mixer is reduced to a minimum and consequently night work is made much easier to handle. Ordinarily the same number of men will be used at the mixer for the night shift as for the day shift. Each man has certain duties which he repeats day after day and learns to perform automatically so that night work is no more difficult than day work.

High power lights are required at the mixer. The most convenient places for these lights are shown in Figs. 1 and 2. It is important that the switching points be well illuminated and that the mixer operators have sufficient light. It is well to have an extra man around the mixer to look after odd jobs and to assist the train men in the rapid handling of cars.

Tamping and finishing machine work follow close upon the mixing operations. This work requires good illumination, but since the use of machines makes the finishing process more or less automatic the chief use for lights is to illuminate the finished surface and to locate any foreign material which may be imbedded in the concrete so that it may be removed before the concrete sets. The night finishing crew is the same size as the day finishing crew.

Curing at Night.—Curing always has been done at night by many contractors. This has been due to the fact that the pumping plant frequently has been so small that it could not supply a sufficient amount of water to provide for the mixer and also for wetting the finishing work. Wetting down the finishing work is, however, more conveniently done in the afternoon.

Covering and all work of similar nature, such as trimming shoulders, etc., should be done by day crews of adequate size.

Form setting should be done in the day and sufficient length of form laid to provide for the night operations. This necessitates more side forms and a larger crew placing forms in the day time. Pumping plants will be operated continuously. Hand lanterns are the only lights necessary at the pumps.

Less Labor Required for Night Work.—For 24-hour day operation three shifts are necessary. It is seldom, however, that more than two shifts are necessary or that it is economical to operate more than two shifts. The following is a list of the actual crew required for a night shift operating two mixers on a 2-mile average haul for materials

Unloading and Hauling:	
Crane operator	1
Crane fireman	1
Clean-up men in cars	2
Train superintendent	1
Engine runners	6
Trainmen	6
Bin gatemen	5
Mixing and Finishing:	
Batch transfer men	1
Track men	2
Mixer operators	2
Firemen	2
Concrete spreaders	4
Finishing machine operators	2
Foremen	1
Pipemen	1
Pump operators	2
Total men for night shift	34

Economies Effected by Night Work.—While a road is under construction, the same rules of business economy apply as in the case of the construction of a city skyscraper. In this work, it is customary to do night work whenever possible, for during the construction period the money invested is returning no income.

The actual loss on a building that costs $500,000 and takes a year to construct is $30,000 based upon interest at 6 per cent. If in the case of one 10-mile section of road the investment was $300,000, the interest loss for this period while the road cannot be used (sections of the road may be in service, but the bad portions reduce hauling efficiency) based on interest at 6 per cent, is $18,000. But this loss is small compared to the loss of time to users of the road and the inconvenience to traffic with the accompanying prevention of profitable hauling. The losses due to these causes are difficult to estimate, but they are large.

From the contractor's standpoint, perhaps the greatest saving from night work comes in the reduction of overhead expense on equipment. This overhead is made up of yearly depreciation (which frequently totals more than the payroll cost of operation), interest, lost time, office expense and other items. The saving in overhead is largely clear profit and may amount to as much as $10,000 on a single season's work on a 10-mile concrete road job.

It must be remembered also that the largest monthly payments are based on completed pavement. This reduces the amount of cash the contractor has tied up. By completing a maximum number of miles in the least possible time the greatest net profits are obtained.

Hauling Over Subgrade in Illinois State Road Construction

The new general specifications for road work of the Illinois State Highway Department contains the following clause:

"Hauling by teams, trucks or otherwise over the finally completed subgrade for a distance of more than 500 feet will not be permitted. If hauling over the subgrade for such distance results in ruts or other objectional irregularities, the contractor shall reroll the subgrade before materials are deposited upon it."

As some misunderstanding has arisen concerning the meaning of the requirement, Mr. Clifford Older, Chief Highway Engineer, has issued the following explanation:

The section is intended to prohibit the contractor from finishing and rolling the subgrade and then hauling all material over it for distances as great as one-quarter, one-half, or even one mile, with the result that the subgrade is rutted and ruined.

Under this section, the contractor may finish his subgrade for any length ahead of the mixer that is desired and may then haul and dump his materials upon it. The only restriction is that the contractor must shape and roll the subgrade at such times as will be necessary to keep ruts out of the subgrade, and, after the final rolling, wagons or trucks must not be run over the finally rolled and completed subgrade for a distance of more than 500 ft.

This may be briefly stated as follows: The distance from the point where the last material was dumped to where the trucks or wagons enter the finally rolled and completed subgrade must not exceed 500 ft.

If hauling over the subgrade for such distance results in ruts or other objectionable irregularities, the contractor shall reroll the subgrade before materials are deposited upon it.

Breaking Up Concrete Pavement with Dynamite.—A blasting mat made of planks was used in breaking up concrete pavement with dynamite. The work was done at Warren, Pa. It involved the removal of a 60 ft. wide by 100 ft. long section of pavement in connection with the grading for the approach to a new bridge. Thirty pounds of dynamite were used to blast out the concrete, which was from 8 to 12 in. thick. To avoid binding the concrete it was shot at angles and great care had to be exercised to avoid damaging the houses that lined both sides of this thoroughfare and to protect from injury the many people who passed this point daily. Instead of a regulation rope blasting mat, which, due to the closeness of the work would only have permitted the shooting of one charge at a time, a special planking arrangement was used which permitted two blasts to be set off at once by battery, each shot consisting of three-quarters of a cartridge. This mat was built of six oak planks, 83 in. long, 16 in. thick and 12 in. wide. These were joined together by two 6 ft. planks 8 in. wide and 3 in. thick The contrivance was reinforced with ordinary boiler iron, each plank being thus lined separately The success of the work is attested by the fact that not a building was marred nor a single window broken in the vicinity As blasting was restricted to certain hours it required six days to complete the work.

Good Roads.*

By RODMAN WILEY,

Commissioner of Public Roads of Kentucky.

Bad Road Tax Is More Than Good Road Tax.—It is no longer a question of not being able to afford good roads because from a plain business standpoint, you cannot afford to be without good roads. The tax for bad roads is many times more than the tax would be for good roads. Consider the country store located 10 miles from a railroad station on a bad road. On every article that is purchased at the store there is a bad road tax, whether it be a plow, a hoe, a pair of overalls or a dress, not because the country merchant is making any more profit than the town merchant but because the country merchant has to pay an enormous price for hauling his goods from the railroad station to the store and that cost must be added to the selling price in order for him to make the same profit that is made by the town merchant.

The question of not having the money to build roads is one that we have framed in our minds, it is not really true. A county will always be poor, financially speaking, if it continues to have bad roads. As a plain business proposition, any man could well afford to take options on the property on both sides of the highway and build that road of good materials at his own expense; because when completed the increase in the property values alone would more than pay for the cost of the road and at the same time leave to him a good profit.

Suppose a road is to cost $20,000 per mile, and that the county's share of the cost is 25 per cent or $5,000. There are 640 acres to the square mile and for both sides of the road that would be 1,280 acres, and if you consider that the country is not benefited for any greater distance than a mile from the road and that the property owners are to pay all of the county's part of the cost, that would mean that they would only have to pay about $4 per acre. Any sensible man knows that a good road will benefit a farm a great deal more than $4 per acre. Besides the country is benefited for a much greater distance than one mile from the road. Why is it that a man will confront such figures and yet not be willing to build good roads? It is one of the best investments in the world. No government, no state, no county, and no individual that has ever built roads is willing to sell the roads for what they cost, which is to my mind sufficient proof that roads are an excellent investment.

Before the farmer would lay aside the cradle and use the modern reaper; before bankers and other business concerns would purchase adding machines; before all business houses would have telephones installed, it was necessary to have a campaign of advertising and education. If such things are desirable, figure what was lost by doing without them, so why cannot we skip the agitation, the educational campaign and build roads NOW instead of waiting a number of years and losing money by having bad roads?

Greater Part of Money Left in County.—If a county should build an earth, gravel or macadam road costing $200,000, and it happened to be of such an assessed valuation that it only paid 25 per cent of the cost, the county's part would be $50,000 and in building the road there would be left in the county at least $150,000 or three times as much as the county furnished. You can easily verify what I have said by going to the records in your own county where state aid work has been done. You will find that practically all the money has been paid out in hiring men and teams and about the only money that leaves the county is that which goes to purchase a few feet of culvert pipe, perhaps a steel bridge or some reinforcing steel.

Sentiment in Road Building.—There is some sentiment in the building of roads. This war has taught us that we should be neighborly. We no longer look upon one of the Allies as being separated from us by a great body of water, but we feel like that we can reach across and shake their hands. It may not be possible for every man in any one county to get a road immediately, but he certainly should not try to keep his neighbor from having a road, and it should be remembered that some one road must be the first road built. If you cannot get your road this year, help some other man get his, and when that road is built you have a much better chance of getting the next one.

Some Men Don't Want Roads Because Land Will Increase in Value.—Some men say that they do not want good roads because roads will not increase the productiveness of the soil, but will increase the price of the land, compelling him to pay more taxes. Such a man is not honest with himself. If a man does not want his farm to increase in value why does he improve that farm by building a good house or a good barn or by rotating his crops to make his land produce more corn and more wheat? Every man wants his farm to increase in value. If a farm located on a bad road is worth $10,000 why would it not be a good investment for any man to help build a road and make the farm worth $20,000? That man would leave to his children 100 per cent more money because the road was built.

False Reports of Costs of Roads.—One thing which retards the road movement is the circulation of false reports concerning the cost of the roads. Some men without any knowledge of the subject make the bold assertion that roads cost too much money. Such an assertion means nothing, carries with it no constructive idea, might be totally devoid of the truth and certainly is dangerous propaganda when uttered by any but those well informed. Such an expression is just as meaningless as it would be to say that a bronze statue cost too much, without taking into consideration the size, installation or character of the work; or that a house cost too much without knowing the number of rooms, the amount of plumbing, kind of finishing, etc.; or that a horse cost too much without knowing whether or not the animal was Dan Patch, Lou Dillon or a common horse seen on jockey ground.

The cost of any road is made up of several items, and the cost of each consecutive mile of any road may vary greatly, depending altogether on what work has to be done on that mile. On the first mile, it might be necessary to move 10,000 cu. yd. of earth, where the next mile may not require 1,000; on the first mile, it may be necessary to install several culverts, to build a few bridges; and on the next mile, perhaps, no drainage structures are necessary. If the road is to be surfaced with stone or gravel, the length of haul will influence the cost of the surfacing on each mile, and certainly such cost will vary unless the length of the haul is exactly the same and unless water is available alike on each mile.

Before making any statement as to the cost of any road, an investigation should be made to find out what is to be done on that road. Add every item, which enters into the cost, and then one can talk intelligently. If that practice is followed, it is easy to see that the only way the cost can be reduced is by eliminating some of the elements that make up the cost.

In this connection, I have observed that there has never been too many culverts built on a road; I have never known bridges to be built larger than is necessary to carry the water; have never seen too much ditching done or the shoulders too well built, and it is seldom indeed that too much metal is used in building new roads. Oftentimes our roads are built entirely too narrow. The cost of building roads has increased, and likewise now the cost of practically everything is more than it was a few years ago.

If roads cost, say, $2,000 per mile when tobacco was selling for 5 ct. per pound, people who make their money by raising tobacco can afford at this time to pay 10 times the former cost, or $20,000 per mile for the same road, because tobacco is selling for 50 ct. per pound today. Many more such illustrations could be given. We should not forget when comparing the cost of things today with what they cost 15 or 20 years ago, we should compare the selling price of our products then and now.

Engineers in Road Work.—Some men, even county officials, have made the bold assertion that they do not want engineers to handle the road work, because they are not practical. Certainly no one wants to employ an impracticable man for anything, whether he be a druggist, a lawyer or a farm hand, and some would be engineers are impracticable, but the same is true of doctors, lawyers and mechanics. Some of the counties in this state have been spending money on roads for 75 years and yet today there isn't a quarter of a mile of good road in the county. That convinces me that the system has been wrong and certainly was handled by impracticable men but not engineers. Every feature of road work is an engineering problem, and practically everything not made by nature that is of use to man is the work of an engineer; to say that engineers are impracticable is untrue in the first place. Engineers design, construct, and maintain our railroads, our canals, harbors, street railway lines, telephone and telegraph lines, electric lighting systems, sewer systems, battleships, locomotives, automobiles and many other things, and how has it been possible to accomplish so much with impracticable men in charge?

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*From an address delivered at Williamsburg, Ky.

If you would have your roads properly constructed and maintained you must furnish the necessary funds and secure the services of a competent highway engineer. Any other plan will prove a failure.

Facts and Figures on City Manager Government

Interesting information as to the rapid spread of the city manager movement and the type of men who are serving as managers is given in the recently published 5th yearbook of the City Managers Association. According to this year book there were 140 towns and cities claiming some variety of city-manager government and 128 managers. The difference between these figures is due chiefly to the fact that several cities have adopted the new plan to become effective at some later date. The reports were compiled from information on hand May 15, 1919.

Three Types of Manager Plan.—The manager plan became effective in more cities last year, during the war, than during any previous year and the year 1919 bids fair to better this record. The figures are: 1908, 1; 1912, 2; 1913, 9; 1914, 17; 1915, 24; 1916, 20; 1917, 17; 1918, 32; 1919 (4 months) 12; 1920 (already adopted), 6; total 140.

These figures include all cities and towns known to be operating under, or pledged to, any one of the three types of manager plan: commission-manager charter; modified manager charter, in which some fundamental principle is lacking; and ordinance-created manager plan, whereby the position is established only by an act of the local governing body. There were 92 commission-manager charters; 10 modified manager charters; 38 ordinance manager plans.

Near-Manager Plans Least Successful.—Judged from the standpoint of "longevity," the attempts to create the city-manager plan by local ordinance have met with but limited success. Out of a total of 57 such experiments, 19 have been discontinued after a short trial,—one out of three have failed. So far, there has not been a single case in which a commission-manager charter has been put in effect by vote of the people and then discontinued. More than that, a study of the tables reveals the fact that the majority of men serving as managers in ordinance-created positions are usually local men of little training and low salary. There are some notable exceptions and where the old type commission form already exists, as in Pennsylvania, the addition of a manager by ordinance approximates the true commission-manager plan.

Choose Non-Residents as First Managers.—Over 63 per cent of cities having commission-manager charters, have selected their first manager from out of town. Frequently his successor has been a local man developed within the organization as an understudy. However, in the modified-manager charter cities, but 30 per cent of the managers have been non-residents, and the same figure holds for the ordinance type towns. The following tables allocate the cities as to size and type, C-M. ch., meaning commission-manager charter; Mod. ch., manager charter with some features lacking; Ord. pl., an ordinance-created plan. The average of the present salaries paid the manager is added.

Plan	Over 50,000.	20,000 to 50,000.	10,000 to 20,000.	5,000 to 10,000.	Under 5,000.	Total
C-M. ch.	11	16	25	22	18	92
Mod. ch.	1	1	3	2	3	10
Ord. pl.	2	0	3	11	22	38
Total	14	17	31	35	43	140
Av. sal.	$6,322	$5,116	$3,016	$2,220	$1,963	

High "Mortality Rate" of Managers.—There have been 229 men appointed as city managers. Of this number, 101 are no longer in the field. There have been 22 cases of promotion from one city to a larger; 4 managers are now serving their third city. Of the 128 listed: only 44 have served two years or over; 39, one; 45 less than one year.

As there are different types of plans, so there are types of managers. Membership in the City Managers Association has been chosen as the arbitrary dividing line in the tabulation. In a sense it serves to classify the types as based upon the training, viewpoint and ambition of the individual manager. All managers having received equally urgent invitation to affiliate with the society, and the annual dues being but nominal (usually payable by the municipality) such membership is a self-classifying shibboleth.

Complete information has not been obtained in all cases and where average and per cents appear in the following summary, only known data is considered. Bureaus of Municipal Research are ranked as colleges and Chambers of Commerce as public service.

SUMMARY OF MANAGER DATA

	Association members	Non-members	Total
Length of Service and Age			
Service			
Over 4 years ...	11	[illegible]	18
2 to 4 years ...	16	10	26
1 to 2 years ...	21	18	[illegible]
Under 1 year ...	15	20	[illegible]
Totals	[illegible]	[illegible]	[illegible]
Age—			
Maximum age ...	62	63	[illegible]
Minimum age ...	28	30	28
Average age ...	[illegible]	45.6	[illegible]
Members, 63% College Men			
College trained ...	38	3	[illegible]
% college trained ...	63%	3[illegible]	[illegible]
Of All Managers 48% Engineers			
Engineers ...	40	12	[illegible]
Public utilities ...	3	4	[illegible]
Public works ...	1	3	4
Accounting and clerical ...		4	[illegible]
Newspaper ...	2	0	2
Chamber of Commerce ...	1	2	3
Business ...	[illegible]	20	[illegible]
% engineer ...	64%	26%	48%
Majority Experienced in Public Service			
Previous public service—			
Engineering and utilities ...	40	10	50
Finance and clerical ...	6	10	16
Public safety ...	2	1	[illegible]
Public welfare ...	3	0	3
Elective offices ...	1	8	[illegible]
Total in public service ...	53	29	[illegible]
% in public service ...	85%	67	77
Local Appointees Less Progressive			
Resident when appointed ...	28	43	71
Non-resident when appointed ...	31	4	[illegible]
% non-resident ...	53%	[illegible]	35[illegible]
Promotions and Salary Increases:			
Promotions—			
To 3d city ...	4	0	4
To 2d city ...	13	1	14
Total promotions ...	17	1	18
Number of salary increases	51	17	68
Salaries Average Over $3,000			
Present salaries—			
$5,000 and over ...	17	2	19
$3,000 to $5,000 ...	27	3	30
$2,000 to $3,000 ...	19	13	[illegible]
Under $2,000 ...	7	32	[illegible]
Average ...	$4,021	$1,964	$3,075

Development of Rural Motor Express.*

By F. W. FENN,

Secretary, Motor Truck Committee, National Automobile Chamber of Commerce.

I am going to tell you of the remarkable advance in highway transportation that has been made in a period of 12 months, as I have seen it. Operating out of Cleveland, the Highways Motor Transport Co. has been making quite a showing, and has been responsible for greater reproduction, because this line has interested the farmer to the extent that he has given more attention to greater production. Six-ton trucks and trailers are being used.

During last summer this company made a remarkable record of hauling hothouse vegetables from Geneva and Ashtabula to Cleveland. When fruits and vegetables began to come into the market, 20,000 crates of berries and 25,000 bu. of tomatoes were hauled to the Cleveland markets. These shipments were followed by 20,000 bu. of apples, peaches and beans. The company hauled 81,000 baskets of grapes into Cleveland last summer. Trailer trains were also used and to show the economy of this kind of an operation, 2[illegible]9 bu. of tomatoes were hauled on the trailer, while the truck carried 291 bu. of tomatoes, 9 bu. of cucumbers, 80 baskets of peaches and 13 cans of cottage cheese. We have paid from 10 ct. to 15 ct. each for apples in New York City because we failed to realize that the finest apples in the world are grown in Connecticut and Northern New York. And so, of course, we buy apples which come 3,000 miles from Oregon and Washington. Just think what the cost of apples would be if we could bring them in from Connecticut in motor trucks—of the great quantities which could come in.

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*From a paper presented May 22 at the Canadian Good Roads Congress.

so that everyone could occasionally eat an apple without feeling guilty.

Another line operating over the Allegheny Mountains from Johnstown, Pa., hauled 115 bu. of potatoes to the load in three hours. The distance of this route is 35 miles.

The Omaha stock yard figures in the haulage of live stock which were published the first of the year have been very interesting. The facts revealed that a greater part of the 250,000 animals delivered from the farms within a radius of 75 miles of the stock yards came in by motor truck.

Short haul lines are not profitable to the railroads. It is on such hauls that motor trucks are demonstrating their value.

Down in Dallas, Texas, W. F. Brittson is operating a rural express train. His trucks go out hauling four trailers to Farmersville, Texas. The load consists of 70 head of sheep; 17 head of steers; net weight of load, 29,500 lb. The distance traveled with this load is 90 miles, 22 miles of which are over black land roads.

The use of motor trucks with the farmer might be said to be developing just as rapidly as the farmer is learning to think in terms of road mileage. When he ceases to think of transportation wholly in terms of horsepower and can comprehend the cost per mile per pound, regardless of the power used, then the sale of motor trucks will be tremendous.

However, trucks are being used to replace railway service, or rather to extend the farmer's marketing radius and to bring the distant city markets within hauling distance of his farm. So we may say that while the truck is being introduced largely because it offers cheaper hauling than the horses, yet a factor almost as important is its ability to do things that are entirely beyond the range of the horse. Probably the best illustration of the latter is the hauling of livestock from the farms to the large packing centers.

"Motor trucks," says E. M. Carroll, traffic manager of the St. Joseph Stock Yards Co., "are being used here to a large extent. We have had truck loads in here from as far east as Chillicothe, Mo., a distance of about 85 miles by rail. We also have received livestock by truck from across the Iowa line, a distance of from 70 to 80 miles. There are trucks making regular trips to the market from points as far as 65 to 70 miles distant. These trucks not only haul hogs, but they also bring in cattle, calves and sheep, and very frequently they bring in mixed loads, separated by partitions. Our largest day's receipts from this source were slightly more than 1,400 hogs and nearly 200 head of cattle and calves and 200 sheep. We did not count the vehicles employed to bring this stock to market, but we estimate that there were close to 250 trucks and wagons, of which 75 per cent were trucks.

"For the 9 months ending Sept. 30, we received from this source 75,211 hogs; for the same period in 1917 we received 33,286; for the entire year of 1917, 56,529, while in 1916 our receipts were 52,048. For 24 days of October this year we received 11,622 cattle, 418 calves, 16,150 hogs, and 25,922 sheep; for the entire month of October, 1917, we received 801 cattle, 877 calves, 5,834 hogs and 1,607 sheep.

"Most of the trucks employed in bringing stock to market are engaged in this business regularly and they range from small trailers attached to the rear end of passenger vehicles to 4 and 5-ton trucks. These larger trucks have a capacity of as much as one-third of a regular railroad car of stock. Many of these trucks are able to get a return load, especially those that come from or pass through inland towns or towns not located on railroads. Some of those trucks are owned and operated by regular dealers located in the country, but the majority of them simply are engaged in transporting livestock and make a charge of so much a head, or load. We believe that this movement is permanent and are going to increase our facilities for taking care of it."

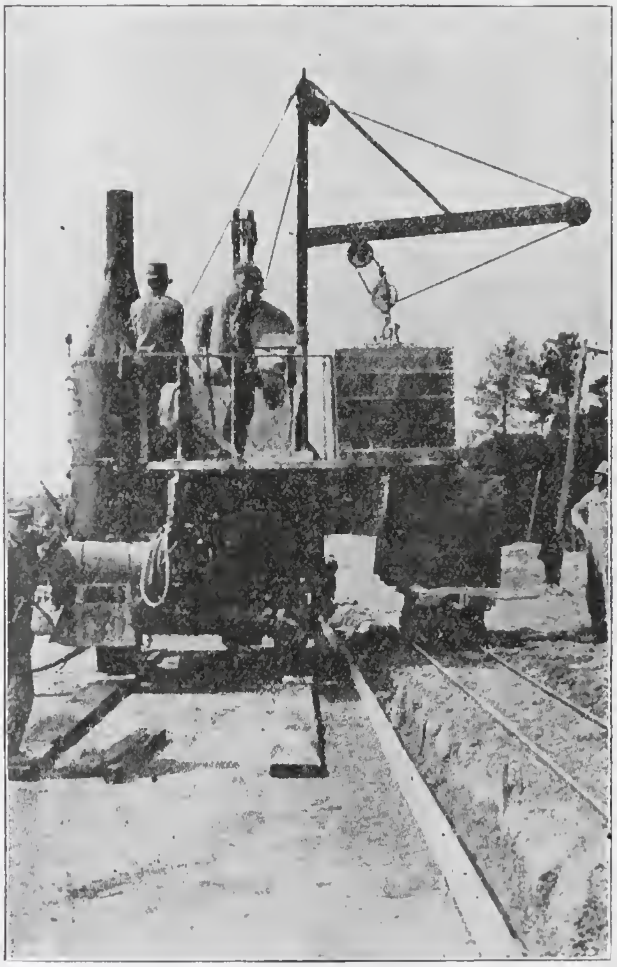
Cost of Concrete Road Maintenance in Milwaukee County, Wis.—During 1918 47.96 miles of Federal aid concrete road was maintained by Milwaukee County, Wisconsin, the total cost for the 485,398 sq. yd. of road surface being $3,099. Of this total $1,706 was for labor and $1,384 for material. The unit cost per mile was $35.57 for labor and $28.85 for material. The cost of maintaining the shoulders of these roads was $197.29 of which $70.87 was for labor and $126.42 for material. The above figures are taken from the last annual report of F. W. Whitlaw, County Highway Commissioner.

Labor Saving Material Handling Plant for Concrete Road Construction

A labor saving storage and loading plant is being employed in the construction of 6.3 miles of concrete road near Laurel, Del. This system is described by Mr. A. R. Losh, Acting District Engineer, U. S. Bureau of Public Roads, in "Public Roads," from which the matter in this article is abstracted.

All materials are received at the central storage and loading plant and are sent direct to the mixer in batch units by means of industrial railway equipment. A general plan of this storage and loading plant is shown in the accompanying drawing.

Stone and sand are received in open cars on the railroad siding (track "A") and are unloaded by means of a clam-shell bucket and derrick working on track "B." The material, if for immediate use, is placed in the bins, which are also operated on track "B" or placed in storage piles for future use. Cement is also received on track "A," and if for immediate use is unloaded onto movable platforms that can be quickly set up conveniently near the car. If the cement is for future use, it is placed in the cement storehouse, from which it is placed on temporary platforms for use as needed.

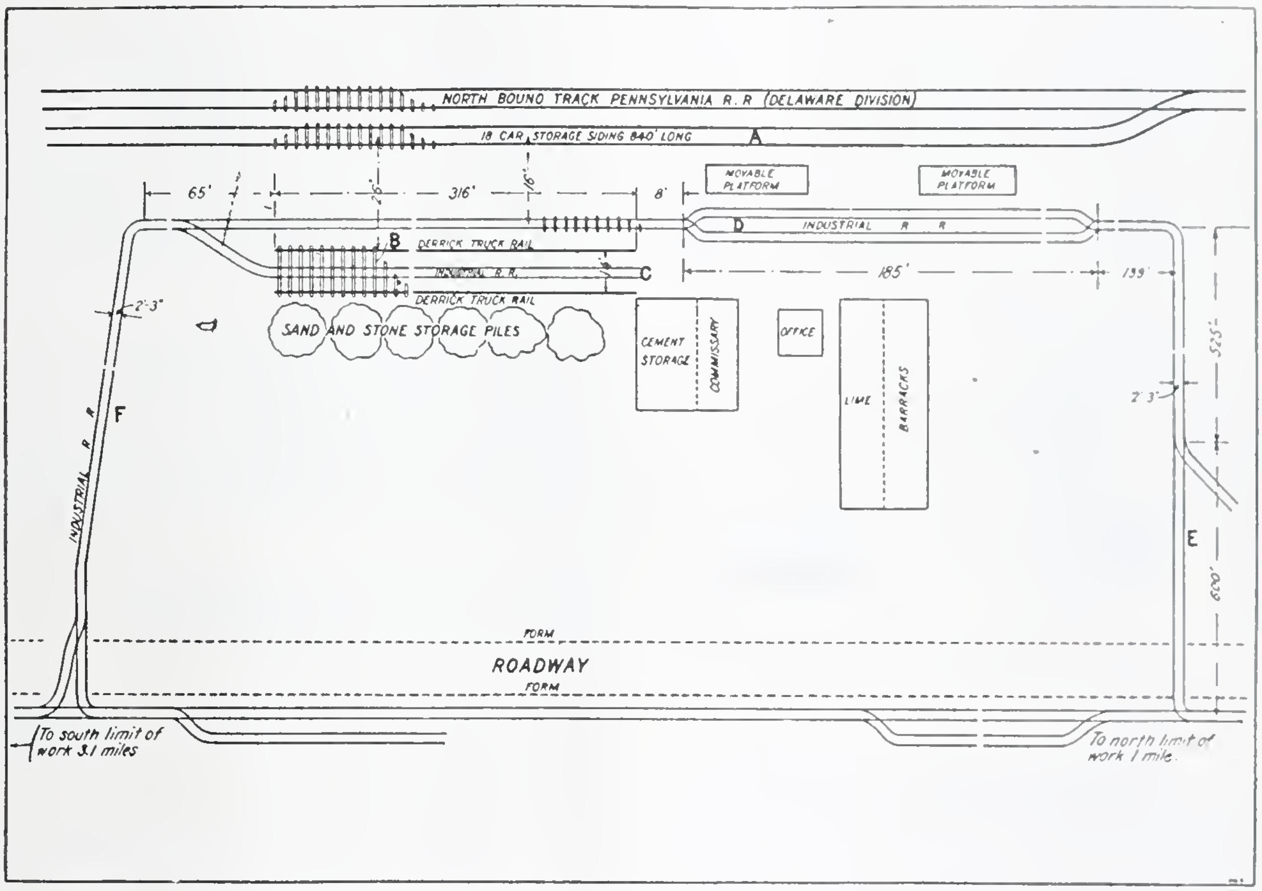


Hoisting a Batch to Dump Into Mixer Drum.

A train to be loaded receives sand and stone on track "C" by passing under the material bins, where the proper amount of each material is dumped into batch boxes. Each car carries two boxes, and a box holds a batch of aggregate. Cement and lime are received from track "D," the cement being left in bags until the mixer is reached. Tracks "E" or "F" are used to reach the mixer, depending upon its location.

Upon reaching the mixer the boxes are hoisted from the cars and dumped directly into the mixer drum. The time required for making the hitch, hoisting and dumping the box, and replacing it in the car is 1½ minutes. The mixer is an ordinary machine remodeled to handle the boxes. The skip has been taken off, but the skip hoist is used to raise the boxes. The mast is an extra heavy 5-in. iron pipe filled with cement mortar and the boom is made up of two 6-in. channels. The mast is stepped into a casting over a worm gear and can be turned through an angle of 160°. This special attachment for handling the boxes was put together by the contractor. The hitch for lifting the boxes is simply a yoke with links on each end which engage strap-iron hooks on the boxes. All special equipment, such as batch boxes, mixer hoist, and stone bins, were made by the contractor and used with his regular construction equipment.

At the present time the contractor has a force of 67 men and the following equipment: One concrete mixer of 1 cu. yd. capacity, 2 gasoline dinky engines, 42 cars, 84 loading boxes, 3½ miles narrow-gage railway, 1 steam roller, 10 teams, 2,500 lin. ft. steel side forms, and in addition the loading plant equipment.



Layout of Storage and Loading Plant for Materials for Concrete Road Construction.

Operating Costs for 3½ Ton Truck

In an address before the Detroit Transportation Association, Mr. C. E. Stone, Transportation Engineer of the J. C. Wilson Co. gave the following figures taken from the cost records of a Detroit owner for the operation of a 3½-ton stake body truck:

Investment—	
Chassis	$3,800.00
Body	350.00
	$4,150.00
Less tires ($74.25 each, 7,000 miles guaranteed)	445.50
	$3,704.50
Costs are based upon 300 working days in the year.	
Yearly Fixed Charges—	
Interest on $3,704.50 at 6%	$ 222.27
Insurance—	
Fire, 75 ct. per hundred	31.13
Collision, full coverage $152, $50 deductible	102.00
Liability (truckman)	135.00
License—	
15 ct. per horsepower (4½x5½—32.4)	4.86
Weight, 15 ct. per 100 lb., chassis 7,000 lb., body 1,800 lb., total 8,800 lb.	13.20
City dray	1.00
Tax 3% on 70% of $4.150 ($2,905)	87.15
Garage, $15 per month	180.00
Driver, $5 per day (300 days)	1,500.00
Per year	$2,276.61
300 days $2,276.61, per day cost	$7.58
Operating Costs—	
Fuel, 25 ct. per gallon, six miles a gallon, per mile	$0.040
Lubricants, 60 ct. gallon, 150 miles a gallon, per mile	[illegible]
Tires, 7,000 miles set, $115.50, per mile	[illegible]
Depreciation carried, $3,704.50 on 100,000 miles, per mile	[illegible]
Per mile	[illegible]
Overhauling, $300 per year	[illegible]
60 miles per day at 155	8.70
Total, daily cost	[illegible]
Per ton mile cost	$0.288

It will be noted that the above figures contain no allowance for the "cost of doing business," which includes general expenses, accidents, bad accounts, etc. To meet these charges this owner charges up $1 a day per truck which he finds about meets the figures. However, he has a general sinking fund of 10 per cent of the daily gross receipts of each truck which takes care of this matter.

Asphalt Production in 1917 and 1918.—According to statistics compiled by the U. S. Geological Survey the quantity of asphalt and allied substances produced in the United States in 1918 was 1,237,853 short tons, valued at $18,540,032, a decrease in output of only 190,473 short tons, or about 13 per cent, but an increase in value of $2,627,604, or 16.5 per cent, compared with the production in 1917, which was 1,428,326 short tons, valued at $15,912,428. The crude native asphalt and allied substances imported for consumption in the United States in 1918 aggregated 115,663 short tons, valued at $814,752, a loss in quantity of 72,702 short tons, or about 39 per cent, and in value of $305,165, or 27 per cent, compared with 1917. The resumption of normal conditions will probably restore the import trade of the United States in asphalt to its pre-war proportions. The quantity of petroleum asphalt (including road oil and flux) produced in 1918 from oil of domestic origin was 527,575 short tons, valued at $7,435,204, a decrease in output of 174,234 short tons, or about 25 per cent, and in value of $299,487, or only about 4 per cent, compared with 1917, but the corresponding material manufactured in this country from Mexican petroleum increased about 1 per cent in quantity and nearly 39 per cent in value. The native bitumens and allied substances, including gilsonite, grahamite, elaterite, bituminous rock, and ozokerite produced from mines and quarries in the United States in 1918 was 60,034 short tons, valued at $780,808, a loss of 24,870 short tons in output but a gain of $44,884 in value, compared with 1917.

Determination of Softening Point of Bituminous Materials

A revised method of determining the softening point of bituminous materials other than tar products was submitted by the Committee on Road Materials at the last annual meeting of the American Society for Testing Materials. This method was proposed as tentative in 1916. The committee, of which Mr. A. H. Blanchard is chairman, recommended that the revision of the ring and ball method be referred to letter ballots of the society for adoption as standard. The proposed standard method follows:

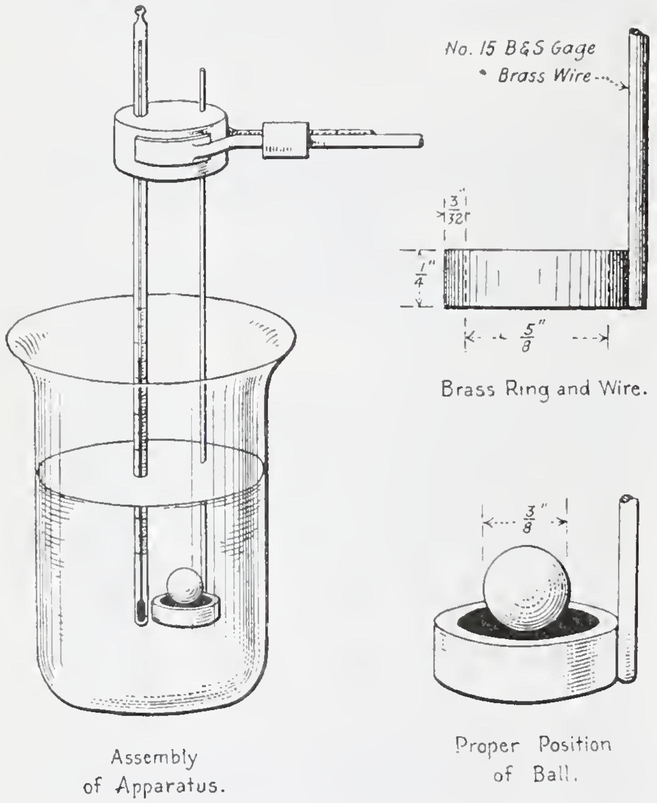


Fig. 1—Apparatus for Ring and Ball Method.

The softening of bituminous materials generally takes place at no definite moment or temperature. As the temperature rises, they gradually and imperceptibly change from a brittle or exceedingly thick and slow flowing material to a softer and less viscous liquid. For this reason the determination of the softening point must be made by a fixed, arbitrary and closely defined method if the results obtained are to be comparable.

Apparatus.—The apparatus shall consist of the following:

A brass ring 15.875 mm. (⅝ in.) in diameter and 6.35 mm. (¼ in.) deep; thickness of wall, 2.38 mm. (3/32 in.); permissible variation on inside diameter and thickness of ring, 0.25 mm. (0.01 in.). This ring shall be attached in a convenient manner to a No. 15 B. & S. gage brass wire (diameter 1.79 mm. = 0.0703 in.). See Fig. 1.

A steel ball 9.53 mm. (⅜ in.) in diameter weighing between 3.45 and 3.55 g.

A glass vessel, capable of being heated, not less than 11 cm. (4.33 in.) in diameter by 14 cm. (5.51 in.) deep. (A 600-cc. beaker, Griffin low form, meets this requirement.)

A thermometer which shall conform to the following specifications:

Total length	370-400 mm.	14.57-15.75 in.)
Diameter	6.5-7.5 mm.	(0.256-0.295 in.)
Bulb length	Not over 14 mm.	(Not over 0.55 in.)
Bulb diameter	4.5-5.5	(0.177-0.217 in.)

The scale shall be engraved upon the stem of the thermometer, shall be clear cut and distinct, and shall run from 0 to 80° C. (32 to 176° F.) in 1/5° C. divisions. It shall commence not less than 7.5 cm. (2.95 in.) above the bottom of the bulb. The thermometer shall be furnished with an expansion chamber at the top and have a ring for attaching tags. It shall be made of a suitable quality of glass and be so annealed as not to change its readings under conditions of use. It shall be correct to 0.25° C. (0.45° F.) as determined by comparison at full immersion with a similar thermometer calibrated at full immersion by the United States Bureau of Standards.

Preparation of Sample.—The sample shall be melted and stirred thoroughly, avoiding incorporating air bubbles in the mass, and then poured into the ring so as to leave an excess on cooling. The ring, while being filled, should rest on a brass plate which has been amalgamated to prevent the bituminous material from adhering to it. After cooling, the excess material shall be cut off cleanly with a slightly heated knife.

Testing.

Bituminous Materials Having Softening Points 90° C. (194° F.) or Below.—Assemble the apparatus as shown in Fig. 1. Fill the glass vessel to a depth of substantially 8.25 cm. (3.25 in.) with freshly boiled distilled water at 5° C. (41° F.) Place the ball in the center of the upper surface of the bitumen in the ring and suspend it in the water so that the lower surface of the filled ring is exactly 2.54 cm. (1 in.) above the bottom of the glass vessel and its upper surface is 5.08 cm (2 in.) below the surface of the water. Allow it to remain in the water for 15 minutes before aplying the heat. Suspend the thermometer so that the bottom of the bulb is level with the bottom of the ring and within 0.635 cm. (¼ in.), but not touching, the ring.

Apply the heat in such a manner that the temperature of the water is raised 5° C. (9° F.) each minute.

The temperature recorded by the thermometer at the instant the bituminous material touches the bottom of the glass vessel shall be reported as the softening point.

The rate of rise of temperature shall be uniform and shall not be averaged over the period of the test. The maximum permissible variation for any minute period after the first three shall be ±0°.5 C. (0°.9 F.). All tests in which the rate of rise in temperature exceeds these limits shall be rejected.

Bituminous Materials Having Softening Points Above 90° C. (194° F.).—Use the same method as given under (A), except that glycerin shall be used instead of water.

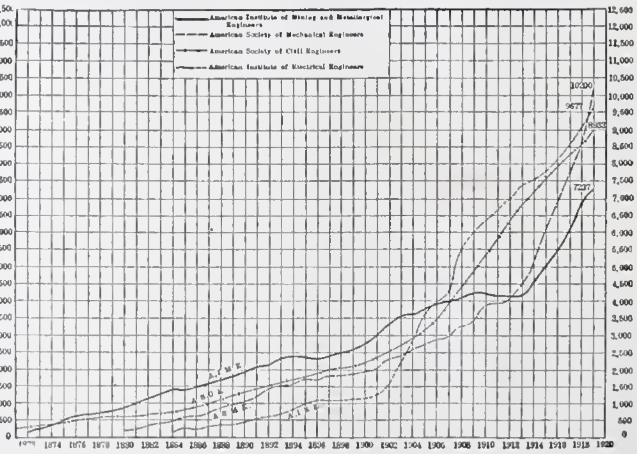
Accuracy.—The limit of accuracy of the test is ±0°.5 C. (0°.9 F.)

Precautions.—The use of freshly boiled distilled water is essential, as otherwise air bubbles may form on the specimen and affect the accuracy of the results. Rigid adherence to the prescribed rate of heating is absolutely essential in order to secure accuracy of results.

A sheet of paper placed on the bottom of the glass vessel and conveniently weighted will prevent the bituminous material from sticking to the glass vessel, thereby saving considerable time and trouble in cleaning.

National Engineering Societies Increased Membership 100% in 10 Years

The number of members in the four national engineering societies has practically doubled in the last 10 years. This interesting fact is brought out in the accompanying diagram reproduced from a recent bulletin of the American Institute of Mining and Metallurgical Engineers.



Increase of Membership Curves of Four National Engineering Societies.

Methods and Cost of Valuing Real Estate in Davenport*

While the assessment of real estate is important, it is equally important that a proper valuation should be made of improvements.

At the time the real estate in Los Angeles was valued, the improvements were also appraised. A group of expert construction men, architects, builders, contractors and engineers were employed. The structures were first classified. Material and labor costs were then made up covering 5 years of varying conditions, and the average costs of all classes some forty odd, were made up on the basis of the reduplication cost new on the 5-year average of prices.

The length of life of structures under varying conditions of maintenance and use was next arrived at, after conferences with experts. This furnished a practical depreciation table in which deduction was made for age and condition. Further depreciation for lack of utility and adolescence were recommended but not adopted.

The building department employed several hundred men familiar with building work and construction to ascertain the mechanical data on each structure in Los Angeles. The building descriptions were recorded on specially prepared slips on which were checked off the details of each building, and on each a sketch was made of the ground floor plan and dimensions. This slip was later turned over to the expert pricers who made a second inspection of the structure, classified it, judged its condition, and applied the cost factor per square or cubic foot which would reproduce the building new at the time of appraisal. Computers in the assessor's office then made the calculations and extended the various items of costs, depreciation, allowance and the final "present value."

A system of valuation similar to the above has been inaugurated in Columbus, East Cleveland, Lakewood, Berea and Chagrin Falls in the state of Ohio; at Springfield, Joliet and East St. Louis in the state of Illinois; in Denver, Colo.; in Houston, Beaumont, Waco, Galveston, San Antonio and Corpus Christi in the state of Texas; in Augusta, Ga.; in Lake Charles, La.; in Portland, Ore.; in Phoenix and Tucson, Ariz.; in Redlands and Los Angeles, Cal.; in Lancaster, Wis.; in Weston, Ont., and in Des Moines and Dubuque in our own state.

The cost of the system in the city of Los Angeles proper was $63,948. This included the cost of valuation of approximately 200,000 buildings. Of this $63,948 approximately two-thirds was expended for the appraisal of improvements, the remainder in land valuation work.

The results in Los Angeles were to increase the assessed value of land $93,227,120 or 21.60 per cent, and to decrease the assessed valuation of improvements $5,576,175 or 3.17 per cent. As a result the tax rate decreased from 94 ct. to 81 ct. in inside districts and from $1.34 to $1.21 in outside districts.

The system to which I have referred was inagurated in the business district of Des Moines in 1913 at a cost of $3,000. It has been adopted throughout the entire city of Dubuque at a cost of $7,500.

An investigation will disclose the following facts with relation to the valuation of real estate in Davenport:

(1) There is no unit basis for the valuation of real estate, and without this there cannot be equitable assessments.

(2) The value of alleys adjacent to property have not been considered on any scientific basis.

(3) The valuations of corner lots have not been and are not founded on any equitable basis. The values as established are largely guesswork.

(4) The assessments of real estate adjacent to corners has no sound basis and reflects in large measure merely the personal opinion of our assessor.

A readjustment of our real estate values would eliminate all four of the objectionable features above referred to.

The system which has been briefly outlined, if adopted in Davenport, would give:

(1) An equitable basis of valuation in which a common judgment would be exercised in every part of the city.

(2) The assessment of real estate would be simplified and therefore more efficiently and accurately made.

(3) Under this system it would be possible for all interested parties to have a voice in the establishment of the land values.

(4) It would in all probability result in an increased income for the city.

(5) It would bring equity and satisfaction to the tax payers. In the opinion of the writer it would be well worth its cost.

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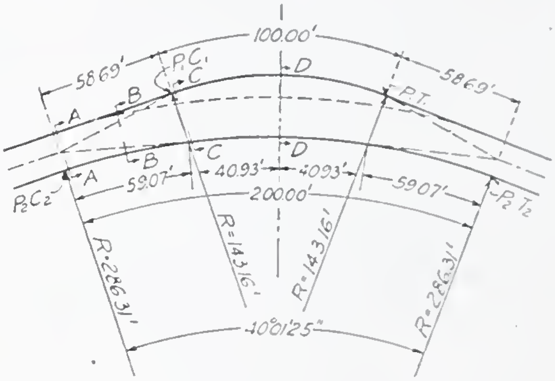
*From an address by W. T. Waterman, before the Contemporary Club of Davenport.

Method of Striking Off Widened and Super-elevated Highway Curves

Not much difficulty is experienced in striking off the inclined surface where the curve attains its maximum super-elevation. It is the surface of the transitory section, bounded by the sections A-A and C-C (see sketch), where most of the difficulty occurs, because this section, which connects the normal surface of the road with the plane section, is necessarily one of a warped nature. Here the line of crown of the normal road surface diverges into two lines, one of which extends from the center of the road at section A-A to the P C of the outer curve—and the other to a point opposite on the inner curve. A method of handling this problem is described by William F. Long in The Concrete Highway Magazine, as follows:



Sketch Showing Method of Widening Highway Curves.

Drive stakes along these two lines at convenient intervals. Cap these stakes with 4-in. channel bars with the flanges facing downward, so that their upper surfaces will conform with the finished grade. Then place concrete in the usual manner. With an ordinary straightedge the triangular plane of this section can be easily struck to grade, the ends of the straightedge resting directly upon the back of the channel bars.

The surfaces on each side of the triangular plane are curved similarly to the normal surface of the roadway. This surface can be formed by the use of a shorter template shaped like that used on the normal road surface. One end should rest on the back of the channel bars and the other on the side forms. The channel bars and stakes are then removed and the grooves and holes made by them are filled with concrete. The surface can then be finished with a roller and belt in the usual way.* It will be found that the resulting surface will very closely approximate the theoretical elevations.

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*This operation will remove any angles which may have resulted in establishing the lines of the triangular plane.

Operating Cost of 5-Ton Dump Truck.—As the result of a questionnaire the Motor Truck Owners' Association of Philadelphia ascertained that the average daily cost of operation for a 5-ton truck of dump body type working under Philadelphia conditions was $26.09, itemized as follows

	Per day.
Depreciation	$ 5.29
Interest	.76
Insurance	1.25
License	.11
Gasoline	3.42
Oil and grease	.42
Repairs	5.11
Garage fees	.74
Overhead expense	1.74
Driver	[illegible]
Tires	[illegible]
Total	$26.09

It also was found out that the fixed charge costs should be based on a 265-day year, and that the average daily mileage was 40½ miles.

Men Who Made the World*

On April 4th occurred the death of Sir William Crookes, and on May 2nd fell the 400th anniversary of the death of Leonardo da Vinci. These two names bring forcibly to mind that civilization is the product of great minds. A constant reader of this Journal writes us the following regarding Sir William Crookes: "A great light gone out, but the vigorous and continuous pulsation emanating from it will shimmer the ether of the universe until time is the sole remaining entity. Ages hence that radiation will illuminate for scientists yet unborn dangerous byways and vague though safe pathways, and hold to course future explorers of Science's realm in search for that most priceless treasure, Truth. This great light shone with a nearly continuous spectrum; there were no dark bands in the visible region, Sir William Crookes was an 'omnitect' of science. He probably knew more about more things than anyone we ever heard of. His work with the spectroscope assured the identification of many elements previously unknown or vaguely classified. What he did in his research on electric discharge in high vacuum ultimately caused a complete revision of our fundamental ideas of chemistry and physics. By following his lead the X-ray was discovered, the telephone amplifier developed, and the most sensitive detector of ether waves evolved. His contribution to our knowledge of the kinetics of gases and radio active bodies was of far-reaching import. The world might lose a million kaisers and all the tangible property that their ambition might doom, yet the real loss would be less than the loss of one man like Crookes. These giants are rare; all the world has seen can be counted almost digitally; in a way they are benign atavisms of evolution. Oh that de Leon had found the Fountain of Youth, or von Helmont the Elixir of Life, that we might prolong in its most virile intensity the life of such a mind among us! It is by the progeny of such minds and by that only that the world's real advancement is achieved."

This is not extravagant. The influence of Hannibal, Alexander, Caesar and Napoleon might be eliminated without impoverishing the world, but without a long succession of men like Crookes there would have been no progress. We should not be much above the plane of the brute creation. The human race lives far more on mind than on matter. Without mind it would be forced to subsist, if at all, on what it could pluck from the bushes. Progress is not the result of mere intuition. It is the product of exceptional minds laboring hard over the facts of life. Civilization has been evolved in just the measure that exceptional minds have discovered the principles that underlie and govern the universe.

In that dreary work, Kant's Critique of Pure Reason, there is a passage on the development of mathematics and physics, the sciences to which the world owes the larger part of its development. "In the earliest times of which history affords us any record," says Kant, "mathematics had already entered on the sure course of science, among that wonderful nation, the Greeks. Still, it is not to be supposed that it was easy for this science to strike into, or rather to construct for itself, a royal road." On the contrary, he continues, "I believe that it must have remained long—chiefly among the Egyptians—in the stage of blind groping after its true aims and destination, and that it was revolutionized by the happy idea of one man, who struck out and determined for all time the path which this science must follow, and which admits of an indefinite advancement. The history of this intellectual revolution—much more important in its results than the discovery of the passage round the celebrated Cape of Good Hope—and of its author, has not been preserved. * * * A new light must have flashed on the mind of the first man (Thales, or whatever may have been his name) who demonstrated the properties of the isosceles triangle. * * * A much longer period elapsed before Physics entered on the highway of science. For it is only about a century and a half since the wise Bacon gave a new direction to physical studies, or rather—as others were already on the right track—imparted fresh vigor to the pursuit of this new direction. * * * When Galileo experimented with balls of a definite weight on the inclined plane, when Torricelli caused the air to sustain a weight which he had calculated beforehand to be equal to that of a definite volume of water, or when Stahl at a later period converted metal into lime and reconverted lime into metal by the addition and subtraction of certain elements, a light broke upon all natural philosophers. They learned that reason only perceives that which it produces after its own design; that it must not be content to follow, as it were, in the leading-strings of nature, but must proceed in advance with principles of judgment according to unvarying laws, and compel nature to reply to its questions. For accidental observations, made according to no preconceived plan, cannot be united under a necessary law. But it is this that reason seeks for and requires. It is only the principles of reason which can give to concordant phenomena the validity of laws, and it is only when experiment is directed by these rational principles that it can have any real utility. Reason must approach nature with the view, indeed, of receiving information from it, not, however, in the character of a pupil who listens to all that his master chooses to tell him, but in that of a judge who compels the witnesses to reply to those questions which he himself thinks fit to propose. To this single idea must the revolution be ascribed, by which, after groping in the dark for so many centuries, natural science was at length conducted into the path of certain progress."

Think what it would mean to the world today if the properties of the isosceles triangle had never been demonstrated! Think what it would mean if Archimedes had never applied mathematics to mechanics! Think what would be our state today if Copernicus, Galileo, Hunter, Davy, Faraday, to choose only a few names at random, had not devoted their lives to a search for the principles by which the universe in its various aspects is regulated!

Those whom we have mentioned are dead. Yet their places must be filled in part at least by others of the same kind if the race is to be kept from taking a fling backward. Throughout the course of human history there has been a continuity of great minds, and the self-preservation of the race will depend on its continuing unbroken. This leads one to ask what is going to be the effect of democracy on the intellectual activity of the future.

Forty years ago a clever Englishman writing on the subject of aristocracy and democracy said: "The customs and convictions of a democracy are more dangerous to intellectual liberty than those of an aristocracy because, in matters of custom, the gentry rule only within their own park-palings, whereas the people, when power resides with them, rule wherever the breezes blow. A democracy that dislikes refinement and good manners can drive men of culture into solitude and make morbid hermits of the very persons who ought to be the lights and leaders of humanity." And in commenting on the Parisian democracy he says: "So far as it is possible for us to understand the temper of that democracy it appears to cherish an active and intense hatred for every conceivable kind of superiority, and an instinctive eagerness to abolish the past; or, as that is not possible, since the past will always have been in spite of it, then at least to efface all visible memorials and destroy the bequests of all preceding generations."

These last words might almost have been written of Bolshevism in Russia. Listen to Lenine, the Bolshevist dictator, talk about money: "Hundreds of thousands of rouble notes are being issued daily by our treasury. This is done not in order to fill the coffers of the state with practically worthless paper, but with the deliberate intention of destroying the value of money as a means of payment. There is no justification for the existence of money in a Boleshevist state, where the necessities of life shall be paid for by work alone. Experience has taught us it is impossible to root out the evils of capitalism merely by confiscation and expropriation, for however ruthlessly such measures may be applied, astute speculators and obstinate survivors of the capitalist classes will always manage to evade them and continue to corrupt the life of the community. The simplest way to exterminate the very spirit of capitalism is, therefore, to flood the country with notes of high face value without financial guarantee of any sort. Already even the 100 rouble note is almost valueless in Russia. Soon even the simplest peasant will realize that it is only a scrap of paper not worth more than the rags from which it is manufactured. Men will cease to covet and hoard it so soon as they discover it will not buy anything, and the great illusion of the value and power of money on which the capitalist state is based will have been definitely destroyed."

There could not be a finer exemplification of the arrogance of ignorance. Lenine says that experience has taught us it is impossible to root out the evils of capitalism merely by confiscation and expropriation, which is true enough; but there is one bit of experience in this very connection which he has altogether failed to note, namely, that while the Bolshevist government, if it may be called a government, has tried to make the Russian peasant sell his crops for worthless paper roubles, it has been unable to accomplish its end. If experience is worth anything in one case it is in another, and the experience of the last year has shown that if the Russian peasant is not allowed the ownership of his crop and the right to sell it on terms satisfactory to himself, he will raise no more than is sufficient for his own keep. Nothing more than this simple fact is needed to demolish Lenine's idea of money completely.

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*From Stone & Webster Journal.

To digress a little, Lenine, and all who think more or less like him regarding capital, fail to perceive a fundamental fact. It is this: though capital is necessarily expressed in goods, or the equivalent of goods, the term primarily signifies mental wealth rather than physical or material. The things which capital in our ordinary use of the term implies are first of all products of the mind. Every act of a man, even those which, as we say, he does without thought, springs from mental volition, though the man may not always take time to note the fact. The more conscious, continuous, persistent the mental volition, the larger and more perfect the product. It is because the mental volition of so large a portion of the race lacks consciousness, continuity and persistency that class distinctions exist to the present extent, and that the world is not much nearer the millennium than is actually the case. Everyone is not born with the aptitude of da Vinci or Sir William Crookes, but everyone, unless born an imbecile, could accomplish vastly more than he does if he pursued the method of Da Vinci and Crookes. They were real capitalists, because they furnished ideas which more ignorant and less persevering persons were able to employ in the daily affairs of life. There is an old saying that knowledge is power, and this is true because knowledge is the real capital of mankind. Labor has always been abundant; brains, however, have been relatively scarce, and brains are capital; so that when Lenine talks about eliminating capitalism he is governed by a suicidal intent.

He seems, however, to realize that the task which he has set himself is not quite so easy as he had supposed. He says, for example, "We have committed many errors in the past, but our disappointment and difficulties were inevitable, for it was impossible to foresee how the social philosophy of Marx, which had never been put into practice before, would work out in actual government." Perhaps no one would have been more surprised than Marx himself at the way Lenine has worked it out. Marx was a man of intellect, but purely a theorizer. His ideas had never been tested by experience; though he stated them with great force and subtlety, his theory was not perfectly concatenated. There were some points which he never was able to explain, indeed never tried to. Certain links were missing. He reminds one of an inventor who once tried to sell capital stock in a company to exploit a new mechanical device. In explaining the device on a certain occasion he showed with admirable clearness what each part was expected to accomplish. When he finished the person to whom he was talking said, "I understand everything about it except the connection between this one particular part and that." The reply was, "That is a secret."

There appears to be a secret in Marx's social philosophy which Lenine has not yet discovered. He has decided, however, to make the best of the circumstances. He says: "The transformation of the capitalistic state into the communist state is impossible wihout the assistance of scientific and technical experts. Inevitably these experts are today bourgeois." Note at this point that he has been busy ever since he came into power in extirpating the bourgeoisie. But to continue—"We have, therefore, been forced to adopt bourgeois methods and to secure the services of the most competent bourgeois specialists by paying them high salaries. It is evident that this measure represents a departure from the principles proclaimed by the Paris Commune, which established that all salaries without exception be reduced to the level of an ordinary workman's wage."

Two interesting questions arise in the mind of one who reads this. How long is this departure from the principles proclaimed by the Paris Commune going to last, and what is going to be the cost to the bourgeois specialists when it ends, if it ever does end, and they are reduced to the level of an ordinary workman's wage? So long as the "departure" lasts we have a fatal admission of the breakdown of the Marx theory. To turn to the second question, will Lenine find it easy to reduce the bourgeois specialists to the level of an ordinary workman's wage? Conceivably it will be just as well for him to put them out of existence when he has used them as much as he wants at high salaries; for if experience teaches anything it is that they will not be worth much to him when reduced to the level he proposes. The bourgeois specialists of Russia may not be great men, but so far as mental capital goes they are greater than the Bolshevists who have been murdering them so freely of late. Woe betide the state that attempts to do business without a considerable amount of mental capital!

We have spoken about Lenine and the Russian Bolshevists because they are extreme cases. No race has ever paid due respect to its great minds, and today the world seems bent on reducing greatness to mediocrity. The present aim of democracy seems to be to produce the average man. This implies a leveling down as well as a leveling up. Of course, if one is born into the world with an investigating mind and a love of knowledge he cannot be altogether prevented from exercising his faculties, but he can be greatly impeded in so doing, and it is comparatively easy to reduce his incentive. Anything that aims at reducing leaders of thought to the ranks is a calamity. Great minds need a proper environment to work in; must be sympathetic and congenial. A great mind cannot work very long under suspicion without losing vitality.

A paradoxical siuation exists today. If we assume that the masses are still eager that great minds shall continue their researches with all their pristine vigor, it is, nevertheless, a fact that those who put principles which they discover in practical application are more or less the object of suspicious, and consequently labor under increasing discouragement. This disparagement of those who exploit great ideas must inevitably react upon the great investigators and weaken their initiative and impair their effectiveness. This tendency exists today, it is unmistakable; but it has not gone far enough to alarm the ordinary mind.

Emerson says that great thoughts rule the world. If this has been true of the past it is because great thoughts have had a congenial world to work in. Great minds were incited to search out great principles because they could expect to see them when found put to work in the practical affairs of life. Imagine a world, however, in which those who put great ideas to work get no larger return than the unskilled workman! Human nature being what it is, such persons, however conscientious, would soon begin to work with diminished energy and lessened interest. The original investigators would soon feel the effect, and their initiative would also be diminished. This would inevitably occur because the world would then be ruled from the bottom instead of the top, and those at the top would feel a sense of isolation which would drive them into solitude. In other words, the persons who ought to be the lights and leaders of humanity would tend to become morbid hermits; a drag would be on everyone's effort.

Emerson also tells us to hitch our wagon to a star. But this would not be possible with a chain on the hind wheel of the wagon. Civilization would decline. For a long time men would eat and drink and try to fancy themselves happy, but the incentive of life would be gone, and sooner or later the emblems of our past civilization would begin to wear out, and eventually we should find ouselves in a dark age surpassing that of one thousand years ago. That is, provided the race remained besotted and failed to perceive the error of its way. Nature, however, seldom allows things to go as far as that. She has sharp, drastic ways of correcting us, and doubtless she will employ them with a free hand.

Traffic on Iowa Roads.—Results of a traffic census by the Iowa Highway Commission indicate that the proportion of farm traffic—from farm to market on main traveled roads—is but 28.6 per cent. Interurban traffic—from town to town—is 46.97 per cent. Town traffic from town to town showed 18 per cent, while tourist traffic averaged 6.5 per cent. It was concluded that two-thirds of the traffic on main traveled highways originated in town and returned to town. It was found that 996 people pass over the Iowa roads per day and an average of 339 vehicles each day. Of these vehicles 86.1 per cent were motor drawn.

Cost and Life of New York State Highway Pavements*

On Jan. 1, 1918, we had in New York state 6,912 miles of pavement of which 5,820 miles were non-permanent types, and 1,092 miles permanent types, of the latter all but 129 miles being of brick or concrete.

Waterbound Macadam.—This pavement is best adapted to the needs of light traffic, but has no place on any through route. It costs today about $23,000 per mile for a 16-26 ft. pavement 9 in. thick (3-in. top on 6-in. subbase). Low construction cost has been the greatest advantage. Its greatest disadvantage now is its high cost of maintenance, which in 1917 amounted to $970 per mile. The average life of this type of pavement is 7 years for a traffic of under 1,000 tons a day. Many waterbound roads have worn out in from 1 to 3 years when called upon to carry a heavier tonnage.

Bituminous Macadam Penetration Method.—This type is also adapted to light traffic generally, and is advantageous in many localities where the only stone available is non-binding. Among its disadvantages is its tendency to creep under traffic. It is slippery when wet; has a fairly high cost of maintenance—$412 per mile during 1917, and a construction cost of $28,500 per mile for a 16-26 ft. pavement 9 in. thick (3-in. top course and 6-in. sub-base bottom course). The average life of this type is 2 years more than that for waterbound macadam under similar traffic conditions.

The determination given for average life of the above types was made in 1917. The much heavier traffic tonnage of today would shorten it considerably.

Concrete.—Has the disadvantage of a glare. It has the advantage of low first cost, $31,200 per mile today for a 16-26-ft. pavement 6 in. average thickness. The maintenance on it in 1917 was $112 per mile. Its average life so far can only be estimated but judging from the condition of 5 to 9-year-old pavements of this type with which I am familiar, we can say at least 15 years.

Brick Pavements.—Most of the sand-cushion type have not been entirely satisfactory for country roads in our climate. The disadvantage of this type was the shifting of the sand cushion with the consequent settlement, breaking and spalling of the bricks. I have no costs for today, as we have ceased to build brick in pavements except as semi-monolithic and monolithic structures. The cost of maintenance was $222 per mile in 1917. Its average life can of course only be estimated, but from present indications I would not place it over 12 years.

Brick Pavements, Semi-monolithic.—This type differs from the original brick pavement in that there is no sand cushion, but the bricks are laid in a cement sand bed and grouted with cement grout to form an integral part of the pavement. This type has the advantage of developing beam strength as in concrete pavement, and eliminates the shifting of and depressions in the brick. Its cost under present conditions would be about $50,600 per mile for a 3-in. brick on a 4-in. concrete foundation. I have no maintenance figures for this type as we have been building it only a little over a year.

Brick Pavements, Monolithic Type.—It differs from the semi-monolithic type in that the brick are set in a green concrete and grouted with a cement grout forming an integral part of the pavement. This type develops the full beam strength and has even greater advantages so far as strength is concerned than the semi-monolithic type. It is more difficult, however, to get as smooth a surface as with the semi-monolithic type.

Asphaltic Concrete.—In order to insure a nearly smooth pavement, a smooth concrete foundation should be provided. These pavements have the disadvantage of pushing under traffic from future consolidation if the aggregate is not properly sized and proportioned or carries too much bituminous material. However, if too little bituminous material is used, the pavement becomes dry and soon disintegrates. The ideal mix is one in which the motor oil dropped from cars renews the volatile oils lost. These pavements cost about $40,000 per mile, depending upon the type, with a 2-in. top and a 5-in. concrete foundation. Their maintenance cost in 1917 was $245 per mile.

There are many patent types of pavement which come under the classification of permanent types and which are good.

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*From a paper presented before the New York Chapter of the American Society of Civil Engineers by H. E. Breed, formerly First Deputy Highway Commissioner of New oYrk State.

The Highway Bond as a "Gilt-Edge" Security.

By B. F. HARRIS,
President First National Bank, Champaign, Ill.

From the standpoint of the banker or investor in municipal securities, capital borrowed for highway development opens the way for a community to divert its highway expenditures from channels of loss to sources of profit—provided the capital is invested in sound construction. If I may be permitted to touch upon engineering principles to make my point clear (and I am sure construction has a vital relation to finance), I would say that we have had sufficient experience to prove that a well built, rigid road surface will insure savings in highway maintenance and vehicle operation to an amount far more than sufficient to cover the cost of sound construction. To these two items in the highway savings account may be added the gain farmers will derive from the removal of weather restrictions and the insurance of dependable marketing conditions.

Totalling the savings from these three sources, we find an accumulating sum that will in due time refund the capital put into the roads, and still leave the public in permanent possession of a paying property. Thus we see how capital invested in sound highway construction may become an agency for increasing community wealth. Viewed in this light, it is readily seen why investors in municipal securities look with greater favor upon bonds where the proceeds are avowedly going into permanent construction. Such a policy helps both parties to the transaction, the public on the one hand with a more economic and durable highway transportation service, and the investor on the other with a guarantee that the capital he provides will be used in a manner that will undoubtedly strengthen the security upon which the bonds are based.

The opportunity to get more capital is found, therefore, in the economies proposed to be effected, and also in the enlarged business which the community will be able to transact. The danger will lie in failure to make the improvements work out according to plan. In other words, if the improvements made are temporary, the earnings or savings will stop short of the total amount of the obligation which has been incurred, and the community will soon find itself back in a financial hole.

The same principle holds true where a county votes to bond and borrow capital for highway improvement. In its transportation department it has certain operating costs that can be reduced by refitting the road surface to the modern wheel. In effecting this change, the cost of vehicle operation both as to wear on the vehicle itself, and the fuel required in creating power to move it, may be reduced to a marked degree.

The opportunity to get capital for sound highway construction is found, therefore, in the need for roads that will permanently eliminate the sources of waste which I have enumerated and which are familiar to all. On this basis, any average county in the United States can present a statement and get funds with which to put a stop to further losses. Its only danger will lie in the appearance of such losses before the highways are paid for. Sound construction in the first place is the only way in which a county or township may insure itself against such a contingency

By building types of road that will last, capital is not only conserved, but returned with a profit, to be reinvested again and again in further public development. Unless this be done, the public is in danger of falling into a period of disappointment as a result of wasted capital, and the ease with which it is now able to get funds for highway building may be converted from an economic advantage to a financial disaster.

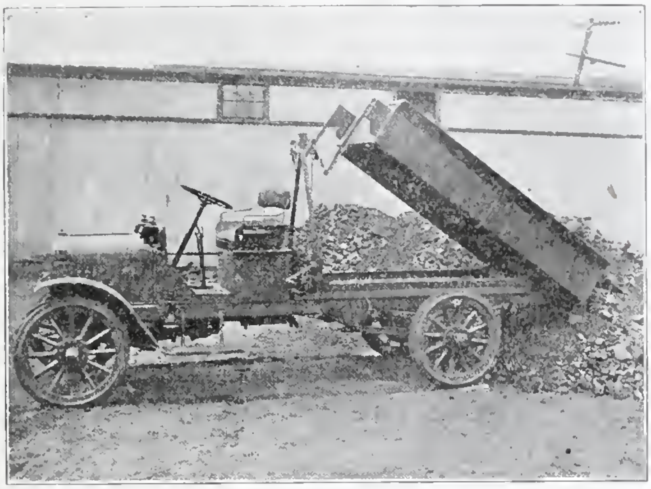
Bad roads are causing enormous losses. Good roads, in the modern sense, will accumulate enormous savings. Capital will effect the change from the former to the latter, provided it is put into sound construction. It is the one way in which to make the highway bond a gilt-edged security.

We have, therefore, a great opportunity for service in urging the construction of permanent systems of roads—county and state wide—and in the purchase of highway bonds as a gilt-edged investment security.

Put your public funds in permanent roads, and your private and trust funds in first class highway bonds, and hail prosperity.

Steel Dump Body With Simple Worm and Gear Hoist.

A light, strong and rugged truck body having features that make it of particular usefulness for highway work is illustrated. The hoist and steel body form one unit and are mounted on one frame. The sub-frame of the body is designed to fit the various widths of all light truck chassis and is drilled ready to attach when shipped. Dumping is accomplished by a worm and gear hand operated hoist of only two moving parts exclusive of pulleys. The hoist takes up 11 in. space on the chassis frame and is operated from either side of the truck. The worm and gear hold the load at an angle without the use of ratchets or other contrivances.



Truck Equipped With 54 Cu. Ft. Economy Steel Dump Body.

A special feature is the tail gate which can be hinged from either top or bottom, and has a scuttle door which can be used for discharging the load in small quantities as in the case of sand or gravel, or in large loads as in the case of coal. The bodies are made in two sizes—54 cu. ft. capacity and 35 cu. ft. capacity. The former body and hoist weighs only 865 lb.; and the latter weighs 700 lb. The bodies are manufactured by the Providence Body Co. and are sold by The Economy Body Sales Co., 405 Lexington Ave., New York City.

Willite Pavement Construction on Los Angeles Boulevard.

A type of pavement, new on the Pacific Coast, is being constructed on the Nigger Slough section of the Los Angeles Harbor Blvd. at Los Angeles, Cal. This pavement is known as Willite; it takes its name from its inventor, the late H. P. Willis, an engineer of the New York State Highway Department. Its principal feature is the intermixture with the asphalt of copper sulphate which is claimed to take from the asphalt it softness and susceptibility to climatic changes and tendency to break down under heavy traffic. The pavement is stated to be composed of about 85 per cent sandy and mixed earth material and 15 per cent asphalt binder tempered with copper sulphate and a small amount of powdered limestone.

In the Nigger Slough work the mixing is done in a Cummer portable road asphalt paving plant having a capacity of 1,250 sq. yd. of 2-in. Willite top per day. This plant is located at the work and the native sandy soil is brought to it by scraper. The soil is thoroughly dried in the plant and mixed with asphalt heated to 350 F. The material, when at temperature of about 300 F., is placed on a wetted rolled subgrade, being spread and rolled in exactly the same manner as sheet asphalt. The pavement is laid in two courses a 3-in. base and a 2-in. top. One day after a section of road is laid it is opened to traffic. The work is being done by the California Willite Road Construction Co. of Los Angeles, Cal.

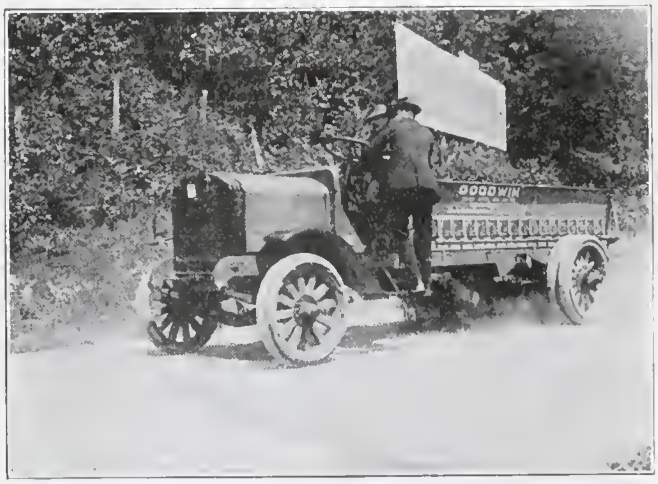
$24,000,000 of Federal Aid Projects Approved in June.—During the month of June the Secretary of Agriculture approved project statements for 133 Federal-aid projects, involving the improvement of 1,390.29 miles of road, at a total estimated cost of $24,220,808, and on which Federal aid in the amount of $11,034,289 was requested. This represents the largest number of project statements approved, the largest estimate of cost, and the largest amount of Federal aid requested during any month since the passage of the Federal-aid road act. During the month there were executed by the Secretary and the State highway departments 60 project agreements, involving the improvement of 507.27 miles of road at a total estimated cost of $7,566,089, and on which $3,404,269 Federal aid was requested and set aside in the Treasury. In addition, 40 project agreements previously executed were amended during the month. Up to and including June 30, 1919, project statements for a total of 1,319 projects had been approved. The 1,319 projects involve 12,790.37 miles of road, a total estimated cost of $133,833,300, and a total of $54,763,957 Federal aid. On the same date a total of 677 project agreements had been executed, involving 5,776.39 miles of road, a total estimated cost of $56,367,334, and a total of $23,892,740 Federal aid.

According to figures announced last month by the State Highway Department of Pennsylvania, there were approximately 300,000 more pneumatic tired vehicles in use in that state July 1, 1919, than there were July 1, 1914. Receipts from all sources July 1, 1919, were approximately $3,330,000 greater than on July 1, 1914. The registrations of solid tired vehicles July 1, 1919, was nearly seven times that of July 1, 1914. Four times as many tractors have been licensed July 1, 1914, as on July 1, 1914.

Construction of 3-in. Willite Base on Los Angeles Harbor Blvd.

Bottom Dump Gravel Spreading Device for Trucks and Trailers.

A bottom dumping arrangement for trucks and trailers is being used quite extensively on gravel road construction and maintenance in the state of Washington. The dumping feature consists of a succession of plates 8 in. wide (depending on the tonnage capacity of the particular truck or trailer) and for the full inside width of the chassis, each plate being pivoted "off center" on a shaft. The plates have a bearing directly over the chassis, and the axis of each is connected up by a lever to a draw-bar carried forward along the sideboard to a segment by which the driver dumps the plates (all at the same angle and at the same time) to unload as much or little as desired. The mechanical lever device is so arranged and adjusted that the plates synchronize perfectly. The plates underlap each other ¼-in., and dump backward and downward 45°, the material dropping through the bottom by gravity. The gravel body is of steel or wood as desired, for the full width and length of the loading area, and of such height (with flare and tail-gate) as loading necessity may require. The bottom-dump and body is clamped onto the truck frame without drilling any holes in the side members or changing the truck in any way. It is claimed that the dumping arrangement will spread the gravel evenly and without leaving it in waves. This bottom dump was patented in 1918 by Mr. W. L. Goodwin, 1515 North 40th St., Seattle, Wash. It is manufactured by the Pacific Coast Engineering Co., Seattle, Wash.



3½-Ton GMC Truck (2½ Cu. Yd. Box) Spreading Gravel at 10 Miles Per Hour. The Man on the Running Board Is in No Way Connected with the Manipulation.

Personals

Victor Conkey has been appointed County Engineer of Tama County, Iowa.

C. C. Hill has been appointed County Engineer of Erie County, Pennsylvania.

R. E. Weeks, of Winnipeg, Man., has been appointed Municipal Engineer of Glenwood, Man.

Ira B. Mullis has been elected county engineer and superintendent of roads for Union County, North Carolina.

Fay, Spofford & Thorndike, Consulting Engineers, Boston, Mass., have removed their offices to 15 Beacon St., Boston.

Maj. W. J. Powell has been appointed County Engineer of Dallas County, Texas, succeeding Mr. J. F. Witt, resigned. Mr. Witt will open an engineering office at Dallas.

Joseph Mercer, formerly County Engineer of Tama County, Iowa, has been appointed District Engineer by the State Highway Department, with headquarters at Oelwein, Ia.

Maj. George K. McCollough, formerly County Engineer of Buena Vista County, has been appointed District Engineer by the State Highway Department, with headquarters at Storm Lake Ia.

George G. Pollock has withdrawn from the Ross Construction Co. and has entered into the engineering construction and contracting business, under the firm name of George Pollock Co Room 1011 Forum Building, Sacramento, Cal.

Prévost Hubbard has resigned as Chief of the Division of Tests and Research of the United States Bureau of Public Roads to accept the position of Chemical Engineer for the Asphalt Association with headquarters at 15 Maiden Lane, New York, N. Y.

Robert B. Hoadley and John A. Giles, who resigned recently as Commissioners of Public Works of Binghamton, N. Y., have organized the firm of Hoadley & Giles, and will engage in a general engineering practice, with offices in the Phelps Bldg., Binghamton. Pennsylvania.

R. S. Currier, who has been district highway commissioner at Montpelier, Vt., for two years, has been appointed assistant to the State Highway Commissioner of Vermont. Earl Hayden of Berlin has been appointed District Highway Commissioner in place of Mr. Currier.

Charles S. Lemon of Hollidaysburg, Pa., division engineer of the State Highway Department, has been appointed engineer for the State Bureau of Township Highways. President Moffat, an assistant engineer, has been named to succeed Mr. Lemon in charge of the Blair, Cambria, Somerset, Bedford District.

Edmund M. Blake has been appointed production engineer for Chas. R. McCormick & Co., 900 Fife Bldg., San Francisco. Mr. Blake is a graduate of Amherst College and of the technical school at Harvard University and his experience covers over 18 years of constructive and executive engineering work both in the United States and Europe. During the war he was engaged in shipyard construction as supervisor of sub-contracts on the victory destroyer plant at Squantum, Massachusetts, and as assistant manager on the Liberty Shipyard at Alameda, Calif.

Industrial Notes

The Chicago Pneumatic Tool Co. announces the appointment of N. S. Thulin as Special Railroad Representative on the staff of Mr. S. C. Sprague, Manager of Western Railroad Sales.

The Ohio Locomotive Crane Co., Bucyrus, O., announces the appointment of H. A. Wolcott as District Manager for the Chicago territory, with offices in the Lytton Building, Suite 1417-19, Chicago.

The Blaw-Knox Co., Pittsburgh, Pa., announces the appointment of Frank O. Leitzell to its corps of engineer-salesmen, in the Sheet and Tin Mill Specialties Department. Mr. Leitzell is a graduate of Pennsylvania State College, '07, and formerly was with the H. K. Porter Co., Pittsburgh, Pa., as assistant to general manager.

The Traylor Engineering & Manufacturing Co. of Allentown, Pa., announces the return of R. R. Shafter to its sales organization after an absence of two years as general superintendent of the shipyard of the Traylor Shipbuilding Corporation. Mr. Shafter as district manager will have charge of the New York office at 30 Church St.

The Hazard Manufacturing Company, of Wilkes-Barre, Pa., on July 1 opened a new sales office and warehouse at 1415 Wazee Street, Denver, Colo., in charge of Ernest P. Kipp, District Manager. The Denver office will cover the Inter-mountain district, including in its territory the states of Colorado, Wyoming, Montana Idaho, Utah, New Mexico, and the western portions of Nebraska and South Dakota

The Chain Belt Co., Milwaukee, Wis., announces the following appointments: Clifford F. Messinger, formerly Manager of Mixer Sales, to become assistant to the Vice-President. Barney F. Devine, formerly Assistant Manager of Mixer Sales, to become Manager of Mixer Sales. Russell E. Dean, formerly of the Rex Mixer Sales Department, to become Eastern Manager of Mixer Sales, with offices at New York City.

Lawrence L. Rogers, formerly treasurer and field manager of Rogers Bros. Co., contractors of Los Angeles, Cal., is now associated with the Lakewood Engineering Co. of Cleveland, Ohio, in the capacity of plant service engineer. Mr. Rogers brings to his new work an experience of 15 years in active construction work. For two years he was in charge of the concrete construction work of the Kalamath Falls Reclamation Project under the supervision of the United States Reclamation Service. He built roads for the New York State Highway Commission near Troy, N. Y., and later his firm constructed 150 miles of macadam and 100 miles of concrete roads in California.

WANTED

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ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials

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Volume LII. CHICAGO, ILL., AUGUST 13, 1919. Number 17.

Slogan for America: Deflate the Dollar

Doubling the cash and bank deposits of an individual doubles his purchasing power. Doubling the cash and bank deposits of all individuals adds nothing to their purchasing power. Comparatively few men, even among those that call themselves educated, appreciate the full significance of this distinction between individual economics and national economics. Had legislators in Europe realized that tripling the currency by printing 36 billion dollars worth of paper money would not help in waging the war, but would triple prices and lead to great industrial confusion, there would have been no attempt to raise the necessary war funds by the aid of printing presses. Had the legislators of America understood the ultimate effect of permitting a billion dollars of European gold to flow into this country in payment for war supplies and food, steps would have been taken at once to prevent such a national catastrophe; for that billion dollars of European gold added to the two billions America already had was certain to raise the price level 50 per cent. Bank deposits in America have long averaged nine times the amount of gold; so when the gold was increased 50 per cent, bank deposits also increased 50 per cent. Since bank deposits serve as currency, it should have been clear to our legislators that if prices were to be held down, bank deposits should also have been held down, which could have been effected by prohibiting the importation of gold from Europe.

But our legislators were ignorant of the principles of economics, and our bankers were either equally ignorant or anxious to profit by the influx of gold and the resulting increase in bank deposits. Our daily papers heralded every shipment of gold to America from Europe as if it were a national benefaction. Yet it was to become a national curse, as any political economist might have predicted, for the influx of gold in large quantities was destined to raise the price level and cause great injustice to those whose incomes did not rise proportionately.

Now, instead of seeking the most practical way of deflating the currency, our legislators are talking of regulating the prices of "necessities." They also speak of investigating "profiteering," as if that were the main cause of high prices. Verily, as Mr. Vanderlip recently said, we are a nation of economic illiterates.

Since the main cause of high prices in America is an inflation of currency and its concomitant inflation of bank deposits, Congress should consult political economists as to the best available way of returning to the old price level. Prof. Irving Fisher, of Yale has proposed increasing the amount of gold in a dollar, so as to decrease the number of dollars of gold in America to the prewar level.

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

The same effect could be secured by gradually increasing the bank reserves, and thus reducing bank deposits. Either plan would probably be opposed by most bankers and by many investors, but the nation as a whole should not be allowed to continue to stew in the existing juice of discontent. Strikes and threats of strikes are increasing in number. Steam and electric railways are on the brink of bankruptcy. All this has come about because average prices have doubled, and that, in turn, is due mainly to currency and bank deposit inflation. Bonds and thrift stamps are also being used as currency, and such use should be stopped by law if possible.

In New York City half a billion dollars are paid annually for rents. Now the landlords are raising rents 20 per cent, and rent riots are imminent. Yet the landlords are merely taking the first step toward bringing their income up to the general price level. A year hence they will add another 10 to 20 per cent, and so on, year after year, until New Yorkers will be paying a billion dollars a year for rent. Yet this doubling in rent in New York and elsewhere will be no more than fair if average prices remain double what they were in 1914.

Politicians are wildly seeking a "goat." Some think they have found that the meat packers resemble a goat more than any other animal. But when the packers point out that they are paying twice as much for meat as before the war, the farmers seem to look like the "goat." Then there is the ever-present middleman upon whom to cast the blame for high prices. So every class blames nearly every other class for the high cost of living, when, in truth, none is to blame except the legislators who were so ignorant of the principles of political economy and the lessons of our civil war as to allow our currency to become enormously inflated.

Deflate the dollar. That should become the slogan of everyone who seeks to reduce the cost of living and return to prewar prices. Since it is the sum of the number of dollars in currency and the number of dollars in bank deposits that measures the totat "circulating medium," that sum should be reduced to the prewar total in dollars. Let Congress call in the specialists to tell them how best to effect this result.

How Civil Engineers Could Reduce the Cost of Food

The Dominion experimental farm at Lethbridge has just published statistics that strikingly illustrate the effectiveness of irrigation even in a climate where good crops are raised without irrigation. During the past 11 years the average yield of Marquis wheat in Southern Alberta has been 30 bu. to the acre, which is almost double the average wheat production of American farms. But many Alberta farmers, not satisfied with a 30-bu. yield, have been irrigating their land. The average production of irrigated land has been 53 bu. per acre. The following data show corresponding results for various crops, column A relating to non-irrigated land, and column B relating to irrigated land:

	A	B
Wheat	30	53
Oats	70	108
Barley	43	78
Peas	27	41
Potatoes	237	487

Land on which "dry crops" are raised in Alberta is always summer fallowed, whereas rotation is followed on irrigated land and a crop raised every year. Irrigated land in Alberta costs twice as much as nonirrigated land, but it is more than twice as productive. Statistics like the above have been gathered in every state of the Union, not only as to the effect of irrigation but of tile drainage. Such statistics make it safe to predict that if civil engineers were employed to solve all the irrigation and drainage problems in America, the output of the average American farm could be doubled. Yet so dense is the present ignorance as to the economic possibilities along this line that America as a whole is making very little progress in land improvement by irrigation and drainage.

Farmers can no longer plead poverty as an excuse for not improving their land, for Uncle Sam stands ready to lend them money at a low rate of interest for a long term of years. The real reason why more farmers do not drain or irrigate their land is their scepticism as to the profitableness of doing so. Were some engineering organization—say, the American Association of Engineers—to conduct an advertising and selling campaign in favor of more general irrigation and drainage under the direction of skilled engineers, there is little doubt that tens of thousands of farmers in the Mississippi Valley and elsewhere could be persuaded to improve their land. The U. S. Department of Agriculture and the corresponding departments of the individual states are slowly educating the farmers to more extensive use of tile drainage and of irrigation, but what is more needed is aggressive advertising and selling propaganda. Perhaps it is premature to expect civil engineers to organize and manage such a campaign, for relatively few engineers have yet come to regard the advertising of engineering services as being professional if the advertising is more than a mere "professional card" giving the engineer's name, specialty and address. The conception of an advertising campaign as being an educational campaign conducted for the profit both of the man who is taught and of the man who teaches, is a conception as yet foreign to most engineers. There still persists the old idea that an advertisement is merely a competitive device to take business away from one's rivals. Associated with this fallacy is another and older mistake, namely, that the gain in every commercial transaction goes mainly, if not entirely, to the seller. This error dies hard, in the face of the fact that the purchaser of a labor-saving device, for example, obviously gains more by its purchase than the seller gains.

If by advertising and by salesmanship, some society of engineers were to persuade 10 per cent of the farmers in America to irrigate or drain their land, thousands of civil engineers could secure excellent remuneration for their services. But large as their gain might be, it would not measure knee-high on the gain that those farmers would make from the increased output of their lands.

Advertising and salesmanship are the machete and the stump-puller that slash through and clear away the forests of ignorance that surround us on every side. If the best known devices and methods were applied universally, the already high output of American workers could be readily doubled. Nothing but ignorance and inertia block our doubling the present outputs per man-day. Inertia and ignorance yield rapidly under the attacks of advertisers and salesmen. But unfortunately no one has yet attempted to sell to farmers the idea of employing engineers to improve their lands; so, despite all the agricultural bulletins that have been issued, the average farmer remains a slave of the two I's—Ignorance and Inertia. At present he is a cheerful slave, for his profits are large as a result of high prices, but the rest of us who pay the prices are not so cheerful.

If civil engineers would break away from precedent and send land improvement salesmen out among the farmers, backed up by convincing advertising, a far greater decrease in the price of foods could be brought about in five years than could be effected in a century of congressional investigation of the high cost of living.

"The Ream County Engineer Act" and Its Significance to All Engineers

Of the 3,000 counties in the United States about 1,700 have county surveyors, many of whom are merely local politicians without any engineering training. Most of these positions are elective, and this probably accounts largely for the fact that so many incompetent men hold the office of county surveyor. In order to change this condition, the State of California has just passed the "Ream county engineer act," under which the board of county supervisors may appoint a county engineer to take charge of all county road work. If 25 per cent of the electors petition the board of supervisors to appoint a county engineer, then the board must do so. A county engineer thus appointed takes over all the duties of an elected county engineer.

We have repeatedly advocated such a step as this. We have urged engineering societies to secure amendments of laws that permit incompetent men to hold engineering positions in counties and municipalities. If local and national engineering societies would only take action, it would not be long before every county and city engineer would be appointed by a competent board of technical men. California has made a step in the right direction, by empowering the boards of county supervisors to appoint county engineers; but boards of supervisors, while much more judicious than voters, are not ordinarily ideal judges of engineering competence.

So long as civil engineers take no active part in securing better methods of selecting city and county engineers, there will continue to be altogether too many incompetent city and county engineers in responsible positions. Moreover, such incompetents will continue to lower the general respect for engineers. With low respect goes a low salary, not only for the incompetents but for the competents.

Book Reviews

Public Utility Rate Fixing.—By C. E. Grunsky, Eng. D. The Technical Publishing Co., San Francisco.

Reviewed by J. C. Black.

This book presents an earnest and straightforward argument for improved procedure in governmental rate fixing. It is not a complete treatise, but is rather an essay on certain phases of regulation, with principal subjects as follows:

(1.) An argument for the regulation of public utility rates so that they shall pay ordinary interest plus a reasonable managerial fee on legitimately invested capital, and in addition a reward based upon the volume of business transacted.

(2.) An exposition of the inconsistency of "value" as a rate base: value being the result of earnings, and therefore not a logical base for regulating earnings.

(3.) An argument that utilities be permitted to share in the general prosperity of the community.

(4.) A criticism of the attempted determination of going value by expert opinion.

(5.) An illuminating discussion of the elements which produce value in reservoir sites and water rights.

(6.) A discussion of water right valuation with recommendation of the "Capitalized Net Profit Method" in cases where actual competition exists; but without final conclusion as to a general method for valuation of water rights.

(7.) An argument against the practice of attempting advance provision for obsolescence and depreciation due to fortuitous events.

The book itself is not divided in accordance with the foregoing list of subjects, and it contains other references of very great value; but the subjects outlined comprise the bulk of the work, and in the opinion of the reviewer are those of first importance.

The fact that the book consists of a series of articles contributed by the author (and one by Capt. C. E. Grunsky, Jr.) to the Journal of Electricity explains its incompleteness of scope and occasional overlapping of discussion. Its merits are such that it is to be hoped that Mr. Grunsky will amplify it into a complete treatise.

The chapters and some of the points made and subjects treated in them are as follows:

I. **General Comments on Rate Fixing:** Accrued depreciation should not affect rates.—Knoxville Waterworks decision criticized in its statement that past earnings should be assumed to have been adequate. This does not permit the introduction of development cost, which is unescapable in most cases.—Adequate earnings include profit.—Gross annual income forms most desirable basis for profit allowance. Express companies cited as examples in which invested capital does not furnish a suitable rate base.—The bonus and the rate base.—Cost and value of water rights in their relation to the rate base. "How to determine the value of a water right is a question which has not yet been satisfactorily answered." Upper and lower limits of possible value are sometimes determinable.—Appreciation in relation to rate base.—Interests of the owner, the rate payer and the public.—Defects in the compound interest method of depreciation calculation advocated by Valuation Committee of Am. Soc. C. E.

II. **Elements Deserving Special Consideration When Rates Are to Be Fixed.**

Obsolescence cannot be predicted and should be amortized after the event.—Amortization of losses from fortuitous events.—Allowance for hazard, for the unearned increment, and for management should not be based on value.—Profit in relation to volume of business. Suggests the advance determination of what profit should be, rather than the determination of profit from values including intangibles difficult of determination.—A tentative table of profits as percentages of gross income for varying volumes of business.—Cost of establishing business is not going value, though it may be indicative of going value.

III. **Appraisal of Real Estate Adapted to Special Use:**

This chapter relates chiefly to water shed and reservoir lands.—Appreciation of land value.—Valuable diagrams of increase of land values with population.

IV. **Determination of the Value of Real Estate in Eminent Domain Proceedings:**

Numerous references to court decisions.—The value multiple, or utility factor. Decision of Minnesota Rate Case criticized, and attention called to the recognition of "value multiple" by the Special Master in the case of the Georgia Railway Co. vs. Railroad Commission of Alabama (Jan. 8, 1912).

V. **Depreciation and Appreciation:**

Mathematical demonstration.—Determination of current replacement requirement essential.—"Must this matter of adding appreciation and allowing a return thereon as though it were additional investment go on forever? If this is the theory its application will hasten universal public ownership of public utilities. Should not a limit be set and thereafter the rate-base remain unaffected by appreciation? The allowance for appreciation, or better, an allowance for participation in general prosperity, should then appear in the earnings. The owner should be allowed a fair amount of current appreciation with which he may do what he pleases, and the public will hold down the rate-base to what is estimated to be the properly invested capital at the time the rate-base was established. The court has apparently overlooked the fact that an unearned increment can be thus allowed in the earnings, and that if thus allowed the public utility which has no appreciating real estate will fare as well as those public utilities which own large areas of land or other appreciating properties."—Rental compared with ownership.

VI. **The Value of a Water Right:**

Average regional cost of development considered.—Strategic value.—Water power development should be encouraged. Mutual irrigation company stock sales as an aid in determining the value of water rights.

VII. **The Rate of Return:**

Protection of the investment.—"The business of every public service concern is subject to regulation and control by properly constituted authority. It will not be going too far to say that any business which is monopolistic in character should be considered subject, at the will of the public, to like regulation and control, even though there are as yet, only the first symptoms apparent that there may in time be a full exercise of the public's right in this direction. But whenever the public controls and regulates a business, particularly in the matter of fixing the price of the output, it is fundamental that any legitimate investment made for the benefit of the public must be adequately protected."—Rate of return defined.—Illustrations.

VIII. **The Rate Schedule:**

Unit price to consumer not uniform.—Unearned increment as a factor.—Determining factors.—The remission of taxes—An interesting section comparing the cases of publicly and privately owned utilities, but offering the generally unacceptable suggestion that taxes be remitted to public utilities.—Discussion of rates for electric energy.—Discussion of gas and water rates.—Discussion of street car fare.—The zone system. Discussion of the railroad rate schedule.—Artificial competition with water transportation.

IX. **The Utility Rate Base:**

Value as a rate base illogical.—The natural rate base—Appreciation and the rate base

X. **Fair Value and the Rate Base:**

Function of rate fixing authorities and of Courts not the same.—The use of value when fixing rates impracticable. Public Service Commission of Washington quoted as endorsing this view.—A satisfactory rate base. "The rate-base which is in every respect most satisfactory is the legitimate, properly determined investment, undiminished by depreciation, but with due consideration to the cost of developing business. That does not meet the decisions of the courts which demand value as the basis of the calculation should not mislead the rate-fixing authorities. They, as already stated, may adopt any proceedings in fixing rates that to them seem fair and proper. It rests with the courts to apply the value test when they are called on to determine the sufficiency of the rates if this be the method they deem proper."

The book contains 170 pages and about 70,000 words. It has a good system of section headings and an adequate index. The type is of good size and the paper dull surfaced so that reading is attended with a minimum of optical fatigue.

While intended primarily for the uses of the advanced student, the excellence of its English and the clearness of its presentation render the work available to the layman who may find it necessary or desirable to give consideration to the subjects treated.

Ports and Terminal Facilities.—By Roy S. MacElwee, Ph. D., Lecturer in Economics and Foreign Trade, Columbia University. McGraw-Hill Book Co.

Reviewed by J. C. Black.

"May these chapters on ports help to point the way to a greater American understanding of the problems involved and to renewed energy of execution. Then will American ports be not only equal to, but far better than any ports yet known abroad." In this concluding paragraph the author states his hopes and the purpose of his book.

Clearly he has produced a work not for specialists in port planning or operation, but for the man who, though ordinarily engaged in other activities, finds it necessary or desirable to familiarize himself with the broader phases of port affairs, port problems, and their solution. Such a book, too, when rightly prepared, may well furnish an introduction to the beginning student. And to the reviewer, this book does appear well prepared. Its English is more than clear: it is attractive. The avoidance of technical detail requiring previous study for its understanding throws the work wide open to any intelligent reader who may wish to enter. The choice of subjects, and the space given to each, seems most wise. That the book is not, after all, complete, is recognized by the author in his preface as follows:

"Several interesting features of the problem, such as finance, dues and income, the combination of beauty with utility in the waterfront, port administration, legal aspects of riparian rights and other points must be reserved for discussion in a possible second volume. The discussion of these points has been omitted not because they are of less importance, but because it must be postponed like so many others until after we have won peace."

The table of contents states clearly the principal subjects treated.

Preface.
Chapter
I. The Nature of the Problem.
II. The Relative Importance and Physical Characteristics of the World's Leading Ports.
III. General Characteristics of a Well-Co-ordinated Seaport.
IV. Port Competition for Rail and Maritime Freight.
V. The Harbor Belt Railway and Competition at the Terminals.
VI. Lighterage.
VII. Cartage, Drays and Motor Trucks.
VIII. Piers, Wharves and Quays.
IX. Wharf Equipment.
X. Cargo Transfer and Handling.
XI. Shed Equipment.
XII. The Warehouse.
XIII. Standard Package or Specialized Freight.
XIV. Bulk Freight.
XV. Inland Waterways and the Seaport.
XVI. The Industrial Harbor and Upland Development.
XVII. The Free Port as an Institution.
XVIII. The Process by Which the Free Ports of Hamburg and Bremen Were Created.
Bibliography.
Index.

The action of proper port facilities as equalizers of the strain upon transportation lines—either rail or water—is emphasized at various places; but "Engineers, port officials, business men, and other progressive citizens are awakening to the fact that expensive harbor works alone, no matter how well constructed, do not make a port which will succeed in bringing commerce and wealth to a city."

The generally broad outlook furnished by the book is illustrated by the following paragraph from Chap. V.

"The luxury of competitive passenger terminals is visible to all. The competition at the terminals for freight is no less keen, although less conspicuous. It is presumptuous to ask the railroad to abandon any advantages which it has gained by years of work and to open its piers to all. Until there is an authority in the country which is higher than the railroads and above reproach of bias, there can be no more hope of the abandonment of this last form of railroad competition than there is of the abandonment of competition in national armaments until there is a world's court and world's police force to protect justly the individual nations. One of the most cogent reasons why American ports are lacking in co-ordination today is because the railroads will not and cannot abandon the last element of competition left to them, the competition at the terminals."

Chap. XV contains a plea for sensible inland waterway development in the United States.

At this time of increasing interest in the subject of "free ports," the discussion of this subject in the two final chapters is illuminating.

Throughout the book there is a liberal use of well selected tabular statistics.

The printing is in good type, but on a semi-glazed paper somewhat conducive to eye strain. This was perhaps considered necessary because of the numerous half-tone illustrations scattered throughout the work; but it is to be hoped that in view of the present knowledge of glazed and dull surfaces in their effect on optical fatigue, publishers will rapidly come to the use of the dull wherever possible, and the use of separate sheets for illustrations requiring a glazed surface.

In the book under consideration, the line drawings are generally excellent in character, though some of them are so greatly reduced that the finer detail is difficult to follow. The subject of the half-tone pictures are excellently chosen, but the reproduction is not generally of the best. The half tone reproductions of maps and plans are as unsatisfactory as such generally are. But these physical imperfections are of small moment in view of the excellence of the text.

Map Reading and Topographical Sketching.—By Edwin R. Stuart, Professor of Drawing, United States Military Academy. McGraw-Hill Book Co., New York, 1918. 140 pages; pocket size; illustrated.

Reviewed by J. C. Black.

The introduction to this little book at once sets forth its purpose as primarily military; and the immediately succeeding pages show it to be for beginners in the subject. Throughout the work valuable suggestions are offered on the relative accuracy of different phases of topographical surveying and mapping. Most of the chapters contain sets of problems to be worked out by the student.

The second, third and fourth chapters of the book deal with map scales, their selection and use.

Methods of topographical surveying for purposes other than military are treated only by reference. Pacing and timing methods are outlined with some care, and as the sufficiency of these methods is too frequently overlooked by ordinary surveyors, the book may be recommended for their consideration.

Chapter V is devoted to conventional signs, all the principal ones adopted by the United States Geographic Board being presented.

Chapters VI and VII treat chiefly of the mapping and use of contours. Hachures, as a means of representing relief are dismissed with a brief comment on their disadvantages and the statement that "The single counterbalancing advantage is that hachures give, in terms of light and shade, a sort of pictorial representation of the ground forms which is intelligible to an untrained eye and to the unimaginative mind." The construction and use of slope scales are well set forth.

Chapter VIII is entitled Map Reference, and relates to the location of points by co-ordinates on map sheets or systems of map sheets.

Chapter IX treats of directions and position on maps, but includes a suggestion on the comparative accuracy attainable in the platting of contours and of topographic details requiring only horizontal delineation, which may well be heeded by every young engineer who is concerned with topography.

Chapters X and XI relate respectively to the plane table and its operation, and to mapping by plane table.

Chapters XII and XIII form a continuation of the subject of mapping, being devoted to sketching and estimating.

The final chapter, entitled "Panoramic Sketching,"with its illustrative examples, shows strikingly how clear a pictorial representation may be made with a minimum number of lines and in minimum time.

Water Expectancy in Mines, Tunnels and Deep Wells in Homogeneous Rocks

In planning deep subsurface structures such as tunnels and mines, it is desirable to form some idea in advance as to the amount of water which will probably be encountered and will require removal. Isolated test shafts are costly, and may not show average conditions. It is desirable to supplement such special data by considerations based on general experience as to the yield of underground water under similar conditions.

Data can generally be secured as to the yield of shallow or surface wells overlying the region where the underground structure is to be made. Such data have been published concerning many conditions and kinds of rock as to the average and usual range of yields of surface wells under different conditions.

In a recent issue of the Journal of the American Water Works Association, Robert E. Horton presents a method and formula by which data obtained from surface wells can be applied, under suitable conditions, to the estimation of the amount of water which it may reasonably be expected will be encountered in any deep excavation.

The method is limited to cases where the bed rock is somewhat uniform in character throughout all depths from the rock floor down to the bottom of the tunnel or other structure. For example, the method will apply to the estimation of probable water in a tunnel in granite, which extends to the surface, but will not apply to a tunnel in deep-seated granite overlain by thick beds of sedimentary rocks.

Without giving details it may be said that there are physical reasons, well confirmed by statistics and experience, showing that the frequency and water-carrying capacity of fissures, joint openings and solution channels in rocks decreases rapidly as the depth increases.

Assume, for simplicity, and as fairly representing experience, that the water-yielding capacity of a given kind of rock varies inversely as the depth, and that q is the maximum yield per square foot of surface at a depth 0 to 1 ft. below the water table. The quantity q corresponds to Slichter's "transmission constant" and its value can be determined from the measured yield of shallow wells in the given location and kind of rock. Then the yield per square feet of surface at a depth h below the surface of the water table may be expressed by the equation

$$q_h = q/h \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The total yield from one side only of a vertical surface 1 ft. wide intersecting the water bearing rock from a depth h_1 to a depth h_2 will be to

$$Q' = q_1 \int_{h_1}^{h_2} dh/h \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

If p is the ratio of the perimeter of a tunnel to its height, or the ratio of the perimeter of a well to its diameter, then letting Q_1 equal PQ^1, where Q_1 is the total yield of a horizontal tunnel per foot of length, or the total yield of a well between any chosen depths per ft. diameter, there follows by integrating

$$Q_1 = q_1 p \left(\log_e h_2 - \log_e h_1\right) \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

If it is desired to determine the total yield of a well from surface to bottom, h_1 should be taken as unity to correspond to the conditions assumed in fixing the value of q_1.

As a practical example, statistics gathered by E. E. Ellis, M. L. Fuller and others show the average yield for numerous shallow wells, on steep, rocky areas, in granitic gneiss and schist of southeastern New York and Connecticut, to be about 4 gal. per minute for 6 in. wells with an average depth in rock below the water table of about 150 ft. The perimeter of a 6-in. well is 1.54 ft. and the corresponding rate of yield for a flat surface 1 ft. wide and 150 ft. deep would be 2.60 gal. per minute. Solving formula (3) for q_1 under these conditions—

$$q_1 = 2.6/\log_e 150 = 0.52 \text{ gal per min.}$$

It should be noted that only wells with little cover of sand or other unconsolidated material have been considered in selecting the value of Q_1 to determine q_1. Shallow wells in rock but with deep cover of loose material often receive much of their supply from above the rock, and may indicate water quantities in excess of the transmission capacity of the rock itself, even at the surface where it is most fissured.

Let it be required to determine the amount of water that will probably be encountered in a tunnel 15 ft. high and with 60-ft. perimeter, at an average bottom depth of 250 ft. below water table in granite gneiss and schist, the length of the tunnel in rock being 11,000 ft. Using the value of q_1 above determined, and solving formula equation (3)

$$Q_1 = 0.52 \times 4 \left(\log_e 250 - \log_e 235\right) =$$
$$0.135 \text{ gal. per min. per ft. of tunnel.}$$

Let Q equal the total infiltration to the tunnel, the length being L. Then $Q = Q_1 L = 1{,}185$ gal. per minute. This indicates that provision should be made to dispose of 1,185 gal. per minute, or something over 2,000,000 gal. per day.

Experience in constructing the tunnel for which data are above given showed an average yield for some time of 1,000,000 gal. per day, and larger yields at times, approaching the amount above calculated.

Like most hydrologic methods and formulas, this one is not infallible, and its application requires intelligent discrimination in selecting surface-well data to determine q_1. It is intended to apply to fissured rocks such as granites, trap, basalt, gneisses, schists, and sometimes limestones and dolomite. It is possible that a large water vein may be encountered which will greatly increase the yield, but the probability of this decreases with increased depth.

In the case of unconsolidated materials and sandstones, the water transmission capacity may decrease little or none with increased depth, and formula (3) does not apply. The quantity of water obtainable from such deposits by means of wells, tunnels and infiltration galleries can be calculated by existing formulas given in various books on water supply.

In the case of shales, experience shows that the water-bearing fissures decrease very rapidly with increased depth, in fact little or no water is generally obtained in dense shales at depths more than 50 to 100 ft. below the rock floor. Observations by the author in the case of many deep wells in Hudson River shale as to the relation of depth to yield is fairly represented by the formula

$$Q_1 = 2q_1 p \left[(1/h_1) - (1/h_2)\right] \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

This is derived on the assumption that both the number and size of connected fissures in shale decrease as the depth increases, or that the transmission capacity per unit of surface varies inversely as the square of the depth. For example, if a 6-in. well extending 20 ft. below water table in shale yields 6 gal. per minute, then solving for q_1p in (1) by taking $h_1 = 1$ and $h_2 = 20$

$$q_1 p = 6/2 \left(1 - 1/20\right) = 3.15$$

To find how much the yield of this well will be increased by extending it to a depth of 100 ft., we have from (1)

$$Q_1 = 6.30 \times \left(1 - 1/100\right) = 6.24$$

The yield of the well would be increased ¼ gal. per minute by extending it from 20 to 100 ft. depth.

The formula indicates that half the water obtainable will be found in the first foot of depth in shale rocks.

This result is certainly of the right order, since experience shows that nearly all the water obtainable in Hudson River shale is often found within 5 ft. below rock surface. A number of wells to depths of over 1,000 ft. in shale in the vicinity of Albany, N. Y., afford their entire yield very near the surface and refute the popular belief that water can always be found in abundance if only a well is drilled deep enough.

Formula (3) can be applied in a manner similar to (1) to determining the probable increase of yield with depth for wells in granite, etc., and indicates little expectancy of increased yield at depths exceeding a few hundred feet, which also is verified by experience.

Formulas (3) and (4) are intended more especially for application to tunnels and mines rather than to wells, since the surface area of ground water interception in the case of the former is much larger and will generally approximate average conditions more closely than for isolated wells.

Settle Septic Tank Claims.—The National Septic Process Protective League has entered into a contract with the Cameron Septic Tank Co. whereby cities and towns are able to settle all claims of that company on the payment of a nominal fee. Under this settlement the amount to be paid is stated to be hardly more than 1 per cent of the royalty claim of the company.

Operating Results of "Direct Oxidation" Experimental Sewage Treatment Plant at Easton, Pa.

In November. 1917, the city of Easton, Pa., granted permission to Mr. C. P. Landreth of Philadelphia, patentee of the "direct oxidation process" of sewage treatment, to construct an experimental plant for treatment of the city sewage. The plant was to have a nominal capacity of 1,000,000 gal. per day and was to be installed without obligation on the part of the city. The plant was placed in operation shortly after May 1, 1918. Tests of the experimental plant were conducted in December, 1918, by engineers of the State Department of Public Health, an 8-hour test run being made on Dec. 4, followed by a 24-hour test starting at 8 a. m., Dec. 6. The results of these tests are given in a report of Mr. C. A. Emerson, Jr., chief of the Engineering Division of the Department. The matter following is abstracted from this report:

The area tributary to the plant is divided into two distinct districts. The first is sewered on the separate system, contributing sanitary sewage only, while the second district contains combined sewers, contributing both storm water and sanitary sewage A survey of the district indicated 585 properties connected to the sewer system as follows: 511 dwellings, 37 combined stores and dwellings, 10 stores, 2 office buildings, 3 hotels, 3 schools, 1 laboratory, 7 churches, 1 armory, 8 garages and 2 breweries. The order of the Federal Government closing breweries became effective four days previous to starting the test of the plant, hence the volume of manufacturing waste discharged from these breweries was much reduced.

The sewage received at the experimental plant appears to be a fresh, domestic municipal sewage of ordinary concentration and composition and passes through a centrifugal pump before treatment.

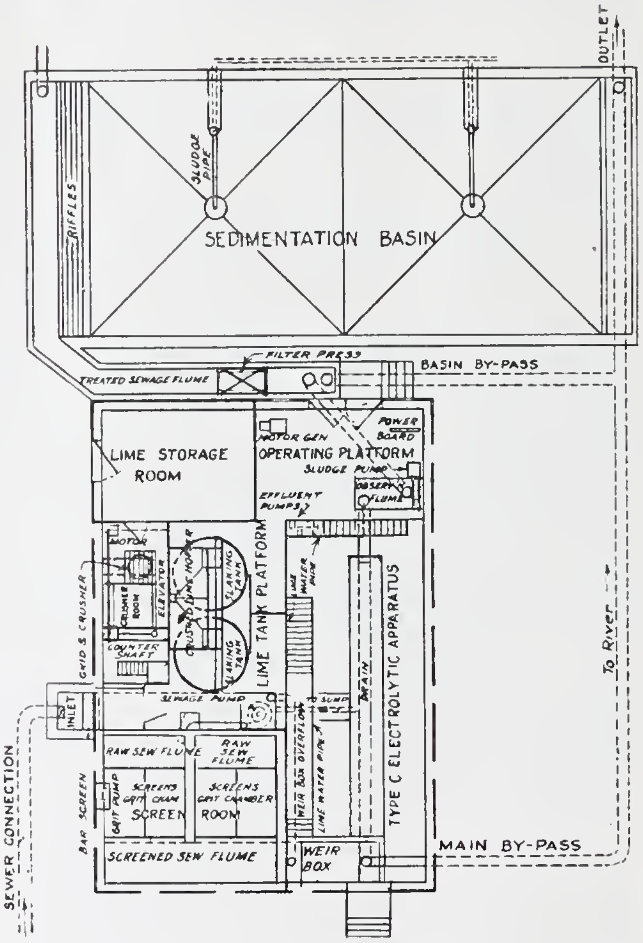
The rainfall during the last part of November, and the few days of December preceding the test was negligible.

The time of passage of sewage from the most distant house in the district to the sewage treatment plant is comparatively short and probably does not exceed 1¼ hours. The low quantity of total solids, suspended solids and oxygen consumed indicate a relatively dilute sewage; the presence in appreciable quantity of nitrates and nitrites and the ratio between the organic nitrogen and the free ammonia contents show that the sewage is quite fresh as treated at the plant. The process of treatment at the plant consists of (1) coarse bar screens; (2) flat plate fine screens, ¼ in. circular openings; (3) grit chamber; (4) chemical treatment—3,720 lb. lime per 1,000,000 gal.; (5) electrolysis; and (6) settlement.

Description of Plant.—Sewage is diverted from 3 ft. by 4 ft. 6 in. egg-shaped combined sewer through a 12-in. pipe, a concrete dam having been constructed in the main sewer immediately below the lateral. At the plant the 12-in. pipe discharges through a 10-in. valve into a covered flume 3 ft. 6 in. wide equipped at its inlet end with a coarse bar screen for the removal of sticks and other large objects. The flume leads to the suction well of a 6-in centrifugal pump which lifts the sewage about 14 ft. 6 in to a raw sewage flume, placed at such an elevation that the sewage can flow thence by gravity through the treatment plant. From this flume the sewage flows on to a horizontal flat plate screen with closely spaced holes ¼ in. in diameter, through which it falls into a hopper-bottomed grit chamber. The raw sewage flumes, fine screens and grit chambers are in duplicate, only one-half being used at a time. The screened sewage overflows from the grit chamber into the screened sewage flume, passes over a 3-ft. weir, is treated with a suspension of lime and then passes through a 12-in. pipe to the electrolytic cell. From the cell the sewage flows through an open observation flume connected to the treated sewage flume and thence over concrete riffles into the sedimentation basins. The two basins are connected in series and have a combined capacity, to the elevation of the outlet weir, of 88,740 gal., giving when clean a detention period of about 2⅛ hours on a flow of 1,000,000 gal. per 24 hours. A 4-in. sludge pipe is provided from each basin to permit of drawing the sludge on to two small sludge drying beds immediately east of the sedimentation basins.

The entire plant, with the exception of treated sewage flume, sedimentation basins and sludge beds, is neatly housed in a sheet iron building 48 ft. 3 in. long and 35 ft. 6 in. wide. The difference in elevation between the fine screens and the overflow weir from the sedimentation basin is 5 ft.

By-pass arrangements permit of running screened or screened and lime-treated sewage from the weir box direct to the river, or of running treated sewage from the treated sewage flume to the river without passing through the sedimentation basins. An overflow pipe in the screened sewage flume diverts any excess over the capacity of the plant, returning it to the pump well. The low concrete dam in the main sewer permits the latter to take the entire flow when the pump is not operated or excess flow in time of storm.



Layout of Treatment Plant.

Electrolytic Apparatus.—The electrolytic apparatus is enclosed in a horizontal wooden tank 27 ft. 3 in. long, 3 ft. wide and 2 ft. 9 in. high (outside dimensions), reinforced with steel plates and mounted on supports 18 in. high. The 2-in. wrought iron vent pipes are carried up from the top of the tank for the removal of any excess gaseous products of electrolysis. A series of blow-out valves are provided along the bottom of the tank.

This tank contains 22 banks of plates, arranged in two layers of 11 banks each. Each bank of electrodes consists of 48 rectangular steel plates 16 in. long, 10 in. high and 3/16 in. thick, placed parallel to the sides of the tank and spaced ⅜ in. apart. The plates are so connected that alternate plates have the same polarity, giving 24 pairs of plates connected in multiple in bank, the 22 banks being connected in series. Spaces between the banks and the sides of the tank are closed, compelling the sewage to flow through the ⅜-in. spaces between the plates. In each space between the plates two straight paddles of Bakelite are revolved, being attached to shafts passing through holes punched in the plates to receive them. The paddles are driven at a speed of 20 revolutions per minute by a 3-HP. motor, the power being transmitted to the paddle shafts through suitable reduction gearing. The total number of paddles in this plant is 2,068.

At the normal rating of the plant, i. e., 1,000,000 gal. daily, the time of passage through the electrolytic cell is approximately 70 seconds, of which 17.4 seconds represent the time of contact with the electrodes, the remainder of the time being occupied in passing through dead space between successive electrodes. During contact the sewage travels in streams ⅜ in. thick for a distance of 14 ft. 8 in. at a theoretical velocity of 0.84 ft. per second.

Lime Apparatus.—Provision is made for using either lump or hydrated lime. When the former is used the lumps are broken by hand on a 3-in. grid placed over a crusher which discharges into an elevator boot. When hydrated lime is used a spout delivers it directly into the elevator boot. The elevator discharges into an overhead hopper from which it is fed dry by adjustable feeding devices to the solution tanks.

The solution tanks are two in number, each 7 ft. in diameter and 3 ft. deep, each with an independent feeding device and agitator. Only one tank is used at a time.

The feeding device consists of a trough with a double worm feed actuated by a ratchet and pawls, which in turn are driven by a reciprocating link attached to an eccentric. The rate of feeding lime to the solution tank my be adjusted within certain limits by changing the throw of the eccentric and by varying the number of teeth engaged on the ratchet by changing the position of the pawl arm.

Either city water or plant effluent can be used in the solution tanks; when the effluent is used it is pumped by a motor driven 1 in. centrifugal pump. In either case, the water enters the tank tangentially near the bottom to help the agitation and the lime suspension or milk of lime is drawn from the top of the tank. Agitation is by means of a two-bladed 10-in. fan placed at the bottom of the tank and operated at 900 r.p.m. by the 1-HP. motor which also drives the feeding device. The circulation is downward at the center and upward at the sides.

Suitable piping delivers the lime suspension into either the spillway of the weir or the observation flume as desired.

Electric motors.—The following is the list of electric motors installed:

For initial pumpage of raw sewage.	1—7½ HP. motor.
For lime treatment—	
Lime crusher	1—5 HP. motor.
Effluent pumps	2—1 HP. motor.
Feeding and agitation	2—1 HP. motor.
For electrolytic cell—	
Paddles	1—3 HP. motor.
Electrolysis	1—5 KW. motor generator set.
For handling grit and sludge—	
Grit pump	1—2 HP. motor.
Sludge pump	1—1 HP. motor.

Of the four 1-HP. motors listed under lime treatment only two would he in service at a time.

Description of the Process.—The process is essentially one of fine screening, followed by lime precipitation, agitation, electrolysis and sedimentation.

The screening through ¼-in. circular openings removes from the crude sewage solid particles of larger size than these openings.

The addition of the lime is claimed by the owner of the electrolytic process to be essential to that phase of the treatment of the sewage, but it should be borne in mind that chemical precipitation of sewage is one of the oldest processes known to the art and produces a very considerable removal of suspended solids.

The electrolytic action liberates nascent oxygen and hydrogen by the passage of the electric current through sewage rendered alkaline by the addition of lime. The agitation, in addition to its well known effect in inducing precipitation, brings the sewage into intimate contact with the products of electrolysis. Chemical reaction is thereby stimulated while the gases are still in the nascent state and before they have an opportunity to escape. The paddles undoubtedly serve also to mechanically clear the plates and prevent polarization.

In normal operation the lime suspension is added to the sewage immediately before entering the electrolytic cell in order to insure positive alkalinity, a condition considered necessary for electrolysis without attack of the electrodes. There is a gradual deposit of calcium carbonate on the plates, which it is claimed can be remedied by temporarily shifting the point of application of the lime to the outlet flume leading from the electrolytic cell. The sewage under such conditions is said to rapidly remove the coating from the plates, permitting normal operation to be resumed in 15 or 20 minutes. A heavy deposit on the plates is indicated by a marked increase in the power required to drive the paddles. No considerable increase was noted during the period of the test.

Some polarization of the plates occurs from time to time, but this is overcome by a reversal of the polarity which quickly decreases the necessary voltage and increases the current.

For satisfactory operation it is said that the cell effluent should contain not less than 30 parts per million of excess alkalinity. During the period of the test this content was always exceeded.

As the sewage reaches the observation flume after passage through the electrolytic cell it contains the lime and the suspended solids. The subsequent sedimentation is to permit the deposition of these materials so as to clarify the effluent and separate the sludge for treatment

Condition of Test.—The plant had been closed since about Oct. 15 and intermittent operation was again resumed on Dec 2, only two days prior to starting the 8-hour test.

During the test the plant was operated by the company. In order that there might be no division of authority and to controvert possible criticism regarding inefficient operation. The Department's representatives observed the operation of the plant, made tests on power consumption, quantity of lime used, flow of sewage and took samples of the sewage, etc.

Prior to undertaking the test all bypass connections were closed and sealed, electric meters and water meters were read and various measurements were made of the dimensions of the units.

During the 8-hour test electric and weir readings were taken at intervals of 15 minutes and at intervals of 30 minutes during the 24-hour test. Samples of the sewage, proportional to the flow, were collected every 30 minutes during the 8-hour test and every hour during the 24-hour test. These were mixed to form composites for chemical analysis for each test run. Settleability and alkalinity samples were collected every four hours and putrescibility, dissolved oxygen and bacteriological samples were collected every 8 hours. Lime samples were collected at irregular intervals, averaging probably two hours, and thoroughly mixed, forming a single sample for analysis.

The Standard Methods of Analysis of the American Public Health Association were followed at the laboratory.

The flow of sewage was determined by weir readings taken every 30 minutes during the tests and varied from a minimum of 309,000 gal. which occurred at 2:30 a. m. to a maximum of 816,000 gal. which occurred at 11:30 a. m. The average flow during the 24-hour test was at the rate of 460,000 gal. per day or slightly less than one-half the rated capacity of the plant.

During the 8-hour test the polarity of the electrolytic cell was changed at 3:23 p. m. in order to decrease the effects of polarization. Immediately after such change the voltage was found to be 40 and the amperage 55. During the 24-hour test a similar change was made on several occasions, but the exact hours were not noted.

At 4:20 p. m. on Dec. 6 a portable voltmeter was applied to the various electrodes to determine whether the total voltage at that time was evenly distributed throughout the electrolytic cell. The results at the outlet end were as follows:

Upper bank	2.8	2.7	2.85	2.7	2.75	2.9	2.95	2.9	3.1	3.0	3.75
Lower bank	3.0	2.7	2.55	2.65	3.0	2.9	2.8	2.75	3.4	2.8	3.15

Immediately after the completion of the test the switchboard ammeter was compared with a portable millivoltmeter with external shunt. The two were found to agree within 2 or 3 per cent.

Summary of Results of Tests.—The following is a summary of the results of the tests

Power Consumption—	8 hr. test.	24 hr. test
Lights and electric heaters	11 K.W. hrs	17 K.W. hrs.
Pump motor	30 K.W. hrs.	90 K.W. hrs
All other power	50 K.W. hrs.	130 K.W. hrs
Total	91 K.W. hrs	267 K.W. hrs
Total water consumption*	66 cu. ft	166 cu. ft
Quantity of lime		1,712 lbs
CaO content		61.52%
Average voltage for electrolysis	56.3	57.5
Average current for electrolysis, amperes	37.8	33.8
Average wattage for electrolysis	2,125	1,914
Average wattage for paddles	1,388	1,355
Sewage flow in gallons per 24 hrs.	482,700	460,000
Average sewage flow in gallons per hour	20,110	19,190
Electrolytic hydrogen liberated in grams per hour	31.04	27.82
Electrolytic oxygen liberated in grams per hour	247.73	222.03
Ratio of electrolytic hydrogen to sewage by weight	0.4 p.p.m	0.4 p.p.m.

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*Includes toilet lavatory and the stuffing boxes of the centrifugal pump.

Ratio of electrolytic oxygen to sewage by weight	3.2 p.p.m.	3.0 p.p.m.

BACTERIOLOGICAL RESULTS.

Figures represent Bacteria per C.C.

	Time.	Raw Sewage.	Screened Sewage.	Cell Effluent.	Basin Effluent.
8-Hour Test.					
Total bacteria	2:30 p. m.	800,000	200,000	38,000	2,000
B. Coli	2:30 p. m.	36,000	24,000	0	0
24-Hour Test.					
Dec. 6—					
Total bacteria	8:00 a. m.	920,000	680,000	24,000	65
B. Coli	8:00 a. m.	100,000	120,000	0	0
Total bacteria	4:00 p. m.	240,000	216,000	2,500	1,500
B. Coli	4:00 p. m.	12,000	50,000	0	0
Total bacteria	12 midnight	48,000	16,000	190,000	18,000
B. Coli	12 midnight	15,000	18,000	0	0
Dec. 7—					
Total bacteria	8:00 a. m.	1,200,000	1,800,000	24,000	30,000
B. Coli	8:00 a. m.	45,000	30,000	0	3

PHYSICAL AND CHEMICAL RESULTS.

	Time.	Screened Sewage.	Basin Effluent.
8-Hour Test.			
Total Alkalinity	12:15 p. m.	106	193
Total Alkalinity	4:00 p. m.	103	326
24-Hour Test.			
Dec. 6—			
Total Alkalinity	8:00 a. m.	98	380
Total Alkalinity	12:00 m.	89	276
Total Alkalinity	4:00 p. m.	88	252
Total Alkalinity	8:00 p. m.	98	282
Dec. 7—			
Total Alkalinity	12:00 midnight	85	288
Total Alkalinity	4:00 a. m.	86	341

SCREENINGS REMOVED.

24-Hour Test.

Bar Screen	117 lbs.
Plate Screen	379 lbs.

RESULTS EXPRESSED IN PARTS PER MILLION.

24-Hour Test.

	Raw Sewage.	Screened Sewage.	Cell Effluent.	Basin Effluent.
Total solids	217	248	608	640
Volatile solids	114	140	196	94
Fixed solids	103	108	412	546
Suspended solids	74	69	215	26
Nitrogen as—				
Organic	34.5	34.2	21.5	21.6
Free ammonia	11.3	11.5	9.2	9.3
Nitrites	0.045	0.05	0.06	0.06
Nitrates	0.46	0.45	0.93	0.90
Oxygen consumed	55	52	44	44

Raw sewage samples were collected from the discharged pipe of the pump after sewage had passed the bar screen. Screened sewage samples were collected after the sewage had passed the bar screen, the pump, the plate screen and the grit chamber. The samples of the cell effluent were taken from the observation flume. This sewage had passed the bar screen, the pump, the plate screen, the grit chamber and the electrolytic cell and had also received the lime treatment.

DISSOLVED OXYGEN.

	Time	Temperature Degrees C.	Content P. P. M.	Saturation. Pct.
Cell influent	10 a. m.	12.0	3.7	34
Cell effluent	10 a. m.	11.0	5.2	47
Cell influent	6 p. m.	12.0	6.8	63
Cell effluent	6 p. m.	11.0	7.0	63
Cell influent	2 a. m.	12.5	6.7	62
Cell effluent	2 a. m.	12.5	8.3	77

PUTRESCIBILITY.

Using Methylene Blue at 20 Degrees C.

	Raw Sewage. Days.	Screened Sewage. Days.	Cell Effluent. Days.	Basin Effluent. Days.
8-Hour Test.				
1:45 p. m.	1	1½	4½	9½
24-Hour Test.				
Dec. 6—				
9:00 a. m.	1	1	14	14
3:00 p. m.	1½	1½	14	12
11:00 p. m.	1½	1½	14	14
Dec. 7—				
7:00 a. m.	1½	1½	14	14

PUTRESCIBILITY OF SLUDGE FROM RESETTLING BASINS.

	100% sludge.	75% sludge, 25% river water.	50% sludge, 50% river water.	25% sludge, 75% river water.	100% river water.
Standard Quantity Methylene Blue Solution	3 hrs.	3 hrs.	3 hrs.	3 hrs.	14 days
3 Times Standard Quantity Methylene Blue Solution	3 days	14 days	1 day	3 days	14 days

In the above table the entries signify the period during which the samples retained a blue color excepting in cases where the entry reads 14 days, which signifies that the color was still present when the samples were thrown away at the end of the 14-day period.

It was feared the bleaching properties of the lime would have a marked effect on the methylene blue solution added to samples of sludge mixed with varying proportions of the river water. Accordingly, the standard quantity of methylene blue solution was added to one set of samples and three times this standard quantity to the check set, including the control samples. It will be noted that the samples of 100 per cent river water were stable for two weeks in both cases but in the other samples, containing varying proportions of sludge and river water, the lime apparently had a perceptible effect upon the methylene blue. The samples containing the greater proportion of methylene blue retained the color for longer periods, although the period of retention of color was not proportional to the percentage of river water, tending to throw some doubt upon the accuracy of this determination.

The appearance of the raw sewage was typical of fresh dilute sanitary sewage from an American municipality except at times when brewery wastes are present.

The effluent from the electrolytic cell had a brownish cast, contained a flocculent precipitate and evidenced tendency to form a floating froth in the observation flume and inlet end of the settling basin. The flocculent precipitate settled rapidly, leaving a clear greenish tinged supernatent liquid excepting when large volumes of brewery wastes were passing through the plant when the effluent from the basin was clear amber color and contained some suspended matter.

There was no opportunity during the test to determine the feasibility of drying sludge from the settling basin upon the sand beds.

At the end of the 24-hour test the cover on the effluent end of the electrolytic cell was removed and the electrolyte drawn down a short distance below the top of the plates. After removal of the coating these plates as far as could be seen were bright and in good condition. The coating, which was removed easily by rubbing with the fingers, was found on analysis to contain 1.73 per cent of iron.

There was no evidence during the test that under operating conditions there is a rapid deterioration of the plates to form a chemical coagulant which was purposely intended in the early processes for the electric treatment of sewage.

Life of Electrolytic Cell.—The company states that the cell under test at Easton had not received any repairs during the summer and in fact the cell cover had not been removed prior to the conclusion of the 24-hour test when it was opened at request of the Department representatives in order to observe the condition of the plates.

Records of electric current consumed during the past summer (May to October inclusive) were obtained from the monthly statements of the local electric company. It was found that the current consumed by the pump would have been sufficient for approximately 18 days' continuous operation and current recorded by the meter supplying circuits for the lime feeding and mixing devices, the solution pump, electrolytic cell and revolving paddles would have been sufficient for approximately 16 days' continuous operation. These periods are obtained by using the current consumption during the 24-hour test as a basis. The higher figure for the pump is probably due to the fact that the flow of sewage was greater on some days than during the 24-hour test while the current required for the lime feed and the cell did not vary uniformly with the flow of sewage.

The company states that the cell remained filled with sewage during periods when it was not operated.

Freedom from Nuisance.—During the Department's test the entire apparatus was free from objectionable odors. Inquiry was made at houses in the vicinity and it was found that the residents quite generally had no cause for complaint.

There is little reason to anticipate nuisance conditions from the screens, cell or settling basins when handling fresh sewage for there would normally be dissolved oxygen present throughout the process. Freedom from nuisance, however, cannot be predicted with any degree of certainty in a large municipal plant which must necessarily contain sludge beds or sludge presses for dewatering the sludge. In fact it is altogether probable that disposal of the sludge would at times be attended by offensive odors.

Cost of Operation.—It is difficult to predict, with a satisfactory degree of accuracy, the cost of operating a large unit by comparison with data collected through operation of a single small unit. However, in the absence of complete information reliance must be placed upon such data as are available and reasonable factors applied to meet expected conditions in the larger plant. The following figures regarding cost of operating the plant at Easton are therefore given as a rough indication of what might be expected but apply more particularly to a plant of a similar size operating under the same conditions, namely, pumping of sewage and the addition of lime at a rate stated by the owner of the patent as being greatly in excess of that necessary to secure satisfactory results:

Without Pumpage—	
Hydrated lime—1,712 lb. @ $6.75 per ton	$ 5.78
Water for mixing lime—20 cu. ft. @ $0.003 per cu. ft.	.06
Electric power—130.6 k.w.h. @ $0.0226	2.95
Electric lights—6¼ k.w.h. @ $0.0805	.50
Heating	1.25
Labor and superintendence	15.00
Electrode renewals—company's estimate	1.00
Maintenance and repair	1.50
Total	$28.04
Add for Pumpage—	
Electric power—88.3 k.w.h. @ $0.0226	2.00
Water—120 cu. ft. @ $0.003 per cu. ft.	.36
Total	$30.40
Equivalent cost per 1,000,000 gals.	$66.00

These figures are on the basis of pumping and treating 460,600 gal. excluding allowance for interest and sinking fund charges and cost of sludge pumping, treatment and disposal. The costs of hydrated lime, water and electric current are those which the Department understands obtains at Easton. The figure for labor and superintendence is based upon employment of a superintendent at $1,650 a year who should be able to make necessary bacteriological and chemical tests and who is familiar with the theory of operation of the process and upon employment of an operator on each 8-hour shift at a salary of $1,200 a year.

If we assume that the plant could be operated continuously at normal rating (1,000,000 gal. a day) the unit costs would be materially reduced and would probably be approximately as follows:

Without Pumpage—	
Hydrated lime—3,720 lb. @ $6.75 a ton	$12.56
Water—20 cu. ft. @ $0.003 per cu. ft.	.06
Electric power—185.5 k.w.h. @ $0.0226	4.19
Electric lights—6¼ k.w.h. @ $0.0805	.50
Heating	1.25
Labor and superintendence	15.00
Electrode renewals	1.00
Maintenance and repairs	1.50
Add for Pumpage—	
Electric power—117.7 k.w.h. @ $0.0226	2.66
Water—120 cu. ft. @ $0.003	.36
Total	$39.08

These figures are exclusive of allowance for interest and sinking fund charges and cost of sludge disposal. It will be noted that the lime has been increased proportionately to the flow as this quantity was added during the test. Should it later appear that the quantity of lime can be reduced without deterioration of the effluent there would be a corresponding reduction in cost of treatment. It is probable that the cost of sludge, pumping, treatment and disposal will be in the neighborhood of $7.50 per 1,000,000 gal.

Conclusions of Engineering Division.—Consideration of the performance of the plant as operated by the owners and as observed by members of the Engineering Division of the Department on Dec. 4 and 6, 1918, lead to the following conclusions:

1. The combined action upon the sewage of the fine screen, lime treatment and the electrolytic cell render the sewage in such a condition that after sedimentation in properly designed tanks the effluent can be discharged into a stream, affording a reasonable dilution of relatively clean water, without danger of creating nuisance. It is of conrse assumed that the effluent will be discharged through properly designed outlet so as to cause dispersion in the stream.

2. The fine screen, lime treatment and electrolytic cell have a destructive action on bacteria of the colon group. If, however, the use of the receiving body of water demands a high degree of bacterial removal in sewage effluents discharged therein, it would be on the side of safety to provide for disinfection of the cell effluent.

3. Assuming fresh domestic sewage, proper design, operation and maintenance of the various devices the treatment of sewage by the above described processes should be free from objectionable odors, with the possible exception of the removal and disposal of the screenings and the sludge from the final settling basins.

4. Similar screenings are being successfully disposed of elsewhere by incineration or burial and the sludge from the final settling basins should be susceptible of dewatering by presses such as are used in sewage treatment works, including the lime precipitation method.

5. The process should be extended by installation of some adequate method for treatment of sludge removed from the settling basins as discharge of this sludge with the cell effluent is not permissible

6. The cost of installation of a sewage treatment works, including the above processes should not be excessive, but the cost of operation would appear to be higher than for other methods of sewage treatment in general use to produce an equal quality of effluent.

Each proposed installation should be examined by comparison with other methods of sewage treatment to determine if savings in installation cost would be sufficient to counterbalance the increased maintenance and operation charges.

If it should be determined that the proportion of lime could be materially reduced without deterioration in the quality of effluent there would be a proportionate reduction in operating costs.

7. To permit continuous operation of a works including these processes, electrolytic cells and other equipment must be in duplicate. It is undoubtedly necessary to replace plates in the electrolytic cell from time to time and accordingly a type of cell should be adopted which admits of such renewals in place and at a minimum cost for labor.

8. The short observations of the combination of fine screening, lime treatment, electrolytic cells and final settlement appear to justify an extended test by this Department should the opportunity be offered. Such tests should include study of results secured with lime additions reduced to the proportion the owner of the patent claims as the actual needs of the process and should also include study of various methods of treatment and disposal of the sludge from the resettling basins.

Cost of Repairing Fire Hydrants by Welding

In a round table discussion of damages to fire hydrants by motor vehicles at the recent convention of the American Water Works Association, Mr. Wm. W. Brush, Deputy Chief Engineer Department of Water Supply, Gas and Electricity of New York City, states that during the past two years an average of about 400 hydrants were damaged yearly by motor trucks, requiring an annual expenditure of about $12,000 for repairs. Repairs are made by welding by the oxyacetlene process. The hydrant is taken to the city shop and the broken section chopped away to a bevel of about 45 , and then new metal is fused in at the break. If the portion of the hydrant thus treated is to be exposed above the ground it is finished off after the welding process is completed. If it is to be below the ground the rough surface is not finished off.

Mr. Brush gives the following costs on this work: The cost of replacing a broken hydrant when the old hydrant is salvaged and repaired, is as follows: welding standpipe of hydrant, $10; assembling hydrant, one mechanic $5 per day, ½ day, $2.50; total cost of repairing salvaged broken hydrant, $12.50. The cost of removing the hydrant where is has to be taken up about 3 ft. below the surface of the ground is as follows:

1 caulker, one day	$ 5.00
2 laborers at $3.25 per day each	6.50
1 Ford car, one day	[illegible]
Relaying 16 ft. of sidewalk at 30c per foot	4.80
Contingency	.70
Total	$2[illegible]0

The greater part of that $20 would be eliminated in the case of a hydrant that has a flange at the level of the sidewalk.

In a same discussion Mr. F. W. Cappeten, City Engineer of Minneapolis, Minn., stated that in his city 43 hydrants had been broken by motor vehicles in 16 months The average expense per hydrant was as follows:

Excavation, removal and resetting	[illegible]
Shop work and assembling	[illegible]
Welding (done by private concerns)	1[illegible].47
Cartage	2.5[illegible]
Total	$31.21

Contract Let for Hetch Hetchy Dam.—The city of San Francisco has awarded the contract for constructing the Hetch Hetchy dam of its new water supply system to the Utah Construction Co., Ogden, Utah. The contract price was $5,447,800. The structure is to be of the siphon spillway type. Bids on the work were opened the latter part of July. R. C. Storre & Co., San Francisco, was the only other bidder.

Motor Truck Mounted Water Purification Units*

By WILLIAM J. ORCHARD,
Sanitary Engineer, Wallace & Tiernan Co., Inc.

The world war brought forth many novel developments in every line of endeavor, the water supply field being one of the many. The portable motor truck mounted water purification units presented nothing new in the fundamental principles of water purification, but show the applicability of the principles used in stationary domestic plants, to portable plants for military use.

In 1914, the necessity for a specially organized water service was not recognized by any of the allied forces, water supply functions being the duty of engineering troops. The purity of the water was determined by the medical department.

The water supply conditions presented in France and in Belgium, and the problems of water supply met in trench warfare, were entirely different from problems presented in previous wars. The soils of northern France and Belgium were for the most part highly cultivated, fertilized for scores of years with night soil, and other refuse, so that water supplies normally obtained in the battle area were highly polluted. Then, too, the German forces in passing over the country indescribably polluted all water left behind when retreating, making special measures necessary for purification.

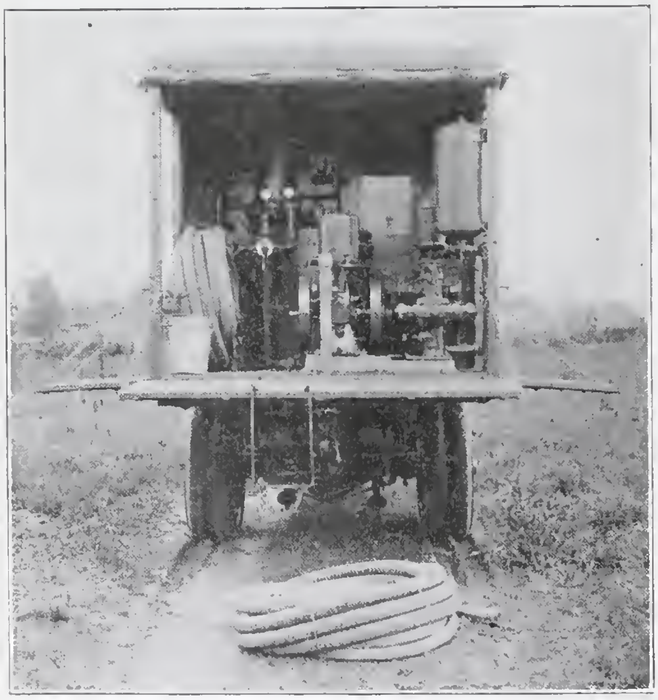

Fig. 1.—Interior View of Truck.

It is reliably reported that the 1915 Campaign of the French Army broke down, largely due to inadequacy of water supply arrangements, and at the close of this campaign, the French war office organized a special water service for the Second French Army, under the direction of Major Bunau-Varilla, well known through his endeavors to construct the Panama Canal with French financial support.

The chlorination of all water supplies used for drinking and cooking purposes was required by the French military authorities. Calcium hypochlorite, or sodium hypochlorite, was applied in such quantities that 15 minutes after treatment there remained two-tenths parts per million of residual chlorine.

It should be pointed out that such excessive amounts of residual chlorine, greatly in excess of American practice, left objectionable tastes and odors in the treated water, so that the troops were apt to take the more palatable, but dangerous, untreated water from flowing streams, shell holes and the like, when possible.

The United States forces in entering the conflict, taking advantage of the lessons learned by the Allied forces, created a water supply regiment, the 26th Engineers, which was officered by experienced water works men, most of whom are members of the American Water Works' Association. This regiment had charge of the water supply of the American forces, both in the advanced area, and in the rear.

Early in the war the need for portable water wagons for the purification or supplies was presented, and bulky equipment with filters and devices for treating the water with hypochlorite were put forth. In 1916 the availability of apparatus of American manufacture to control liquid chlorine made possible the first efficient motor truck mounted water purification unit.

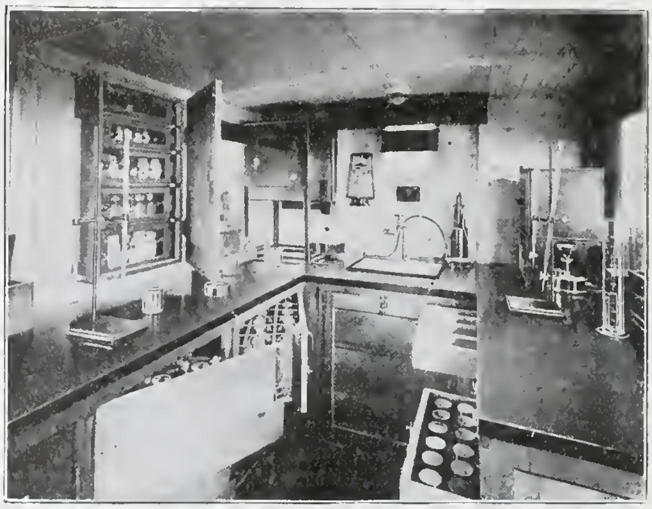

Fig. 2.—Laboratory Arrangement.

When this country entered the war we believed that the experience we had gained through co-operation with our British house in construction of equipment for the British forces should be placed at the disposal of the military authorities. With this in view equipment based on the British unit, but modifying the typically English characteristics to introduce American methods and equipment was constructed and tested under varying conditions at Maplewood, N. J. Water was taken from the west branch of the Rahway River, a grossly polluted stream.

This first unit was equipped with rotary pumps, which did not prove suitable, and subsequent units were equipped with gasoline operated force pumps. Various members of this association, who were officers in the Engineer Corps, or in the Sanitary Corps of the army, offered helpful suggestions and contributions toward the development of this unit, which, when placed in operation, gave highly satisfactory results.

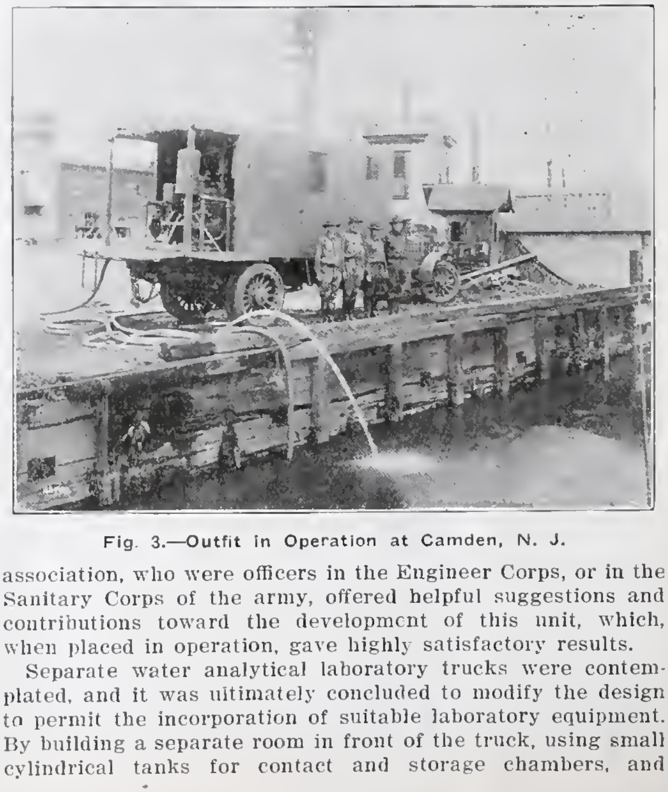

Fig. 3.—Outfit in Operation at Camden, N. J.

Separate water analytical laboratory trucks were contemplated, and it was ultimately concluded to modify the design to permit the incorporation of suitable laboratory equipment. By building a separate room in front of the truck, using small cylindrical tanks for contact and storage chambers, and placing these tanks under the laboratory benches, a marked saving in the space required was effected.

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*Abstract of a paper presented at the 39th annual convention of the American Waterworks Association at Buffalo, N. Y., June 9-13, 1919.

Description of Operation.—The water is pumped through a 50-ft. suction line of 2-in. steel woven suction hose fitted with bronze check valve and strainer, by the gasoline engine operated pump, located at the rear of the body. A very heavy dose of chlorine is applied in the pump suction, from a manually operated solution feed chlorinator, located on the rear wall of the laboratory room. When waters of low alkalinity are treated, soda ash is applied with the chlorine solution into the pump suction.

Passing through the pump, with a relief valve set to operate at 50 lb. pressure, the water is passed to a specially designed pressure filter, being treated with alum through the standard dash-pot arrangement en route.

From the filter the water passes through a 1½-in. water meter, thence through a diaphragm pressure regulating valve to maintain constant back pressure on the chlorinator water supply line, thence through the storage and contact tanks located beneath the laboratory benches, to the point of discharge at the forward left-hand corner of the truck. Just at the point of discharge the water is treated with sodium thiosulphate solution regulated and controlled by a special dechlorinating equipment.

These units were designed, having in mind the grossly polluted and befouled waters that would have to be treated, and based on the British practice and experience, high doses of chlorine were introduced into the raw water. The filters served to clarify the water, and the point of discharge.

It was thought necessary to make provision for removing the excessive residual chlorine that would be in the water after passing through the contact tanks, and a proportional pressure feeding thiosulphate dosing device was developed. It should be mentioned that provision for dechlorinating was made in accordance with the British experience, who used the process of dechlorination by the application of compressed sulphur dioxide gas in all of their portable units. On the British truck the sulphur dioxide was controlled by a standard direct feed manually controlled chlorinator of American manufacture.

In the American truck, the chlorinator used was the standard manually controlled solution feed type. Control valves for the soda ash and thiosulphate solutions were in the rear of the laboratory below the chlorinator so that all chemical application could be centrally controlled by the laboratory operator.

The first several trucks were constructed with horizontal pumps, and it was found that special provision was required to eliminate excessive vibration in the laboratory. With this in view, special spring supports were developed. On the later trucks a vertical force pump was used and this so eliminated the vibration as to obviate the necessity of special spring supports.

The development, construction and testing of the first lot of trucks, and the tests and recommendations of the Board of Inspection Officers, representing the office of the Chief of Engineers, the Engineer Depot, and the Sanitary Corps of the Army, resulted in many modifications of design and rearrangement of equipment, but not in any change in the basic principles involved.

The value of these units became so apparent that increased facilities were required for their manufacture. An admirable factory in Camden, N. J., was obtained, and here in conjunction with our construction work, a school for Sanitary Corps men, members of the Water Tank Train, and officers who were to have charge of the trucks in operation, were conducted.

Figure 1 is a rear view of the completed truck with the rear and side gates let down for operation. It shows the gasoline storage tank to the right of the pump, and provisions made for carrying and chaining the suction hose.

The laboratory arrangement in the final truck is shown in Fig. 2. The provision made for carrying chemical bottles is indicated, as is also the sink for washing glassware, and a hand air pump for creating pressure in the storage tanks when the pumping equipment is not in operation. A 37 degree incubator for bacteriological samples, oven for sterilizing glassware and electric lighting equipment, are included in the outfit, while in the rear of the laboratory is a standard solution feed chlorinator, and thiosulphate and soda ash controls. On the bench, beside the chlorinator, is a pressure auto clave for sterilizing purposes.

Figure 3 shows one of the trucks in operation at Cooper Creek, Camden, N. J.

The very best materials available were used in the construction and assembly of the units. The first several trucks were mounted on 3½-ton White truck chassis, but by far the largest number were mounted on 5-ton 17-ft. wheel base Pierce Arrow chassis. Novo 3-HP. gasoline engines were used, with Gould 5-in. by 5-in. force pumps. The filter was constructed by the Roberts Filter Mfg. Co., the electric lighting equipment by the Vesta Storage Battery Co. The rated capacity of the unit was 1,000 gal. per hour, although the actual delivery was nearer 1,500 gal.

The support of the filter, which weighed 2,400 lb. without the water, presented problems that required careful study. The final solution was to fasten 5-in. steel H-beams to the chassis frame by 1" bolts, bolting the filter to the H beams by feet cast on the special filter base.

These units rendered valuable service under actual military operation in France. Some of them were injured by shell fire and some of the Sanitary Corps men wounded in operating the units near the firing line.

Cost Figures on New Sooke Lake Water Supply System, Victoria, B. C.

In a paper in a recent issue of the Journal of the Engineering Institute of Canada, Mr. C. H. Rust, formerly Water Commissioner of Victoria, B. C., gives some cost data on the construction of the new Sooke Lake Water Supply project of Victoria. The original contract for the work called for the clearing of the land around the lake 15 ft. above low water; the construction of a dam at the foot of the lake, with necessary screen house, intakes, etc.; the construction of 27 miles of concrete pipe 40 in. in diameter (this involved the building of 27 miles of railway track 2 ft. gage); the construction of 6 siphons and the necessary concrete trestles, and temporary wooden trestles carry the track; the construction of a telephone line; the building and clearing of a reservoir site; and the erection of a dam, screen house, valve chamber, venturi meters, etc., at Humpback, which is about 12 miles from the city; and the building of 11 miles of 36-in steel pipe, leading to the city reservoir.

Construction was started early in 1912 but the contract was abandoned in April, 1913. The city then proceeded with the work by day labor, a large force of men being placed at various camps. The laborers were paid $2.75 per 8-hour day, $1 a day being deducted for their maintenance. The city completed the clearing of the land at Sooke Lake, carried out the construction of the dam, head works, etc., at the foot of the lake, and built the dam at Humpback.

The actual cost of the work carried out by the city, according to Mr. Rust's paper, was as follows:

Sooke Lake:	Per cu. yd.
Earth excavation in construction of dam at Sooke Lake.	$ 1.42
Rock excavation	4.21
Concrete in foundation of dam	15.68

All the cement had to be shipped by rail and hauled by teams about 10 miles over very rough roads. The gravel and cement were procured from the upper end of the lake, and had to be towed to the foot of the lake. This involved the placing of a tug in the lake which had to be transported from Victoria over the mountain, and the construction of scows.

Concrete Pipe-Line:	Per lin. ft.
Pipe	$2.[illegible]2
Concrete trestles	.1[illegible]
Railroad	.5[illegible]
Transportation	[illegible]
Total	$3.36
Telephone Line:	
Cost per mile	$12[illegible]
Steel Pressure-Line:	Per ft.
36 in.—5/16 in.	$5.[illegible]
36 in.—3/8 in.	[illegible]

The city did the earth excavation and backfilling at the following cost:

	Per cu. yd.
Earth excavation	$1.[illegible]2
Backfilling	.56

Contractors' prices were as follows:

Humpback Reservoir:	Per cu. yd.
Earth excavation	$ [illegible]0
Rock	1[illegible]
Clearing (per acre)	605
Placing gravel in bottom	2.[illegible]8
Concrete foundations for dam	9.[illegible]0
Concrete in dam	1[illegible].65

These prices included, plant, tools, equipment, supplies, bookkeeping, etc.

The total earth excavation amounted to 180,331 cu. yd.: total rock excavation was 150,517 cu. gal.

Concrete Sewer Pipe Specification of American Concrete Institute Committee

"Proposed Standard Specifications for Monolithic Concrete Sewers and Reinforced Concrete Pipe Sewers and Recommended Rules for Concrete Sewer Design" is the subject of a report submitted by a special committee on Concrete Sewers at the recent convention of the American Concrete Institute. The specifications are given in Volume XV, 1919, of the Proceedings.

These specifications are a revision of those submitted by the committee at the 1918 meeting, and, in addition, there have been introduced specifications for concrete pipe sewers. The following digest emphasizes the general features.

Part. I. Materials.—The material specifications apply to concrete materials, reinforcement castings, and material for invert lining. Individually, they conform to the American Society for Testing Materials' specifications and those used on general construction work with the exception of specifications covering the use of crushed stone which "shall have a coefficient of hardness of not less than 16 as described in Bulletins Nos. 347 and 370 of the U. S. Department of Agriculture and applies more particularly to locations where limestone or sandstone of a questionable value are common."

Part II. Concrete for Monolithic Concrete Sewers.—This part specifies the concrete mixtures to be used, the method of mixing, the transportation and placing of concrete, the type and construction of forms and the placing of reinforcement.

Part II-A. General Construction, Monolithic Sewers.—Specifications in this section cover the width of trench and provisions for underdrainage of work in the progress of construction. A granolithic finish is specified which is to consist of one part of cement to two parts of granite or other hard rock chips graded from ⅛ in. to ½ in. in size, and shall be laid 1½ in. thick on the fresh concrete as soon as the condition of its surface will permit. Where required, sewer inverts are to be lined with concrete block, tile, or vitrified brick. Backfilling is to be placed as soon as possible after cement has set.

Part III-A. Manufacture of Reinforced Concrete Pipe.—Reinforced concrete sewer pipe shall be made in sizes from 24-in. to 96-in. inside diameter. It shall be in sections of not less than 3 ft. in length. Steam curing is permitted. Crushing tests specify that the pipe shall withstand for a knife-edge bearing, 2,149 lb. per lin. ft. for a 24-in. diameter pipe up to 3,521 lb. per lin. ft. for a 42-in. diameter pipe. Equivalent sand bearing loads are from 3,070 lb. per lin. ft. for a 44-in. diameter pipe to 5,030 lb. per lin. ft. for a 42-in. diameter pipe. Certain other tests are also specified.

Part III-B. Laying the Pipe.—In general, this section specifies that spigot end of pipe shall be laid towards the outfall and that cement joints shall be used.

Recommended Rules for Concrete Sewer Design.—Concrete sewers without reinforcement are approved for sizes between 30 in. and 60 in. mean diameter and are to be used only in rock or hard soils. The minimum thickness for a sewer 36 in. or less in diameter should be 5 in. and for a 5-ft. diameter 7 in. with intermediate sizes in proportion.

The reinforcement for circular pipe shall consist of one or two rings of steel wire fabric or rods of the areas shown in the following table:

Size, in.	Minimum Thickness of Shell, in.	Cross Sectional Area of Steel per lin. ft. of Shell.
24	3	1 concentric ring of .058
27	3	1 concentric ring of .068
30	3½	1 concentric ring of .080
33	4	1 concentric ring of .107
36	4	1 concentric ring of .146
39	4	1 concentric ring of .146
42	4½	1 concentric ring of .153
48	5	2 concentric rings of .107
54	5½	2 concentric rings of .126
60	6	2 concentric rings of .146
66	6½	2 concentric rings of .168
72	7	2 concentric rings of .180
84	8	2 concentric rings of .208
96	9	2 concentric rings of .245

The thickness of pipe walls shall be as set forth in the following table, but thinner walls may be used provided the amount of steel reinforcement is increased to give sufficient strength to withstand the crushing loads specified.

All sewers near the surface and subject to moving loads or vibration, should be reinforced. For sewers of 6 ft. or less in diameter, it is recommended that the reinforcement be ½ of 1 per cent placed near the inside at the crown, and near the outside at the springing lines.

If it appears at all possible that the horizontal pressures on the sewer might be large, reinforce for reverse stresses.

It is recommended that for all sewers greater than 6 ft. in diameter, several possible types of loading be assumed and stresses be calculated on the elastic arch theory.

It is also suggested that in sewers of greater than 6-ft. diameter, it may be found economical to adopt a section having a comparatively flat bottom, and an arch with or without intermediate side walls.

The minimum thickness of concrete in sections of this type should be 8 in. This is recommended as a factor of safety against poor placing and also to secure waterproof structures.

Helpful Books for the Home Gardener

The average home gardener does not always get the best results from his work. In fact, in many cases all that he knows about vegetable raising is obtained from the directions on the seed packages. The water works superintendent can render a great service to the community and to his company by furnishing information to these gardeners. Some water companies—the Denver Water Co. for one—have issued pamphlets for the guidance of water users in home gardening. A wealth of information on this subject can be obtained from Government bulletins. There are also many other free publications, among these being:

"Grow a Vegetable Garden," published by the Agricultural Extension Department of the International Harvester Co., Chicago, Ill.

"Victory Gardening," by the National War Garden Commission, Washington, D. C.

"The Home Yard Garden," Horticultural Department, University of Illinois, Urbana, Ill.

In a recent issue of the Chicago Daily News, Mr. J. H. Prost, City Forester of Chicago, gives the following list of garden books:

"Garden Steps," by Ernest Cobb, is a manual, about 225 pages of instructions for the amateur in vegetable gardening. I can especially recommend it for the young folks. It is published by Silver, Burdett & Co., Chicago. It is a good little book for the beginner, but not thorough and extensive enough for the experienced gardener.

"Garden Guide," "The Amateur Gardeners' Handbook," is edited by J. Harrison Dick and published by A. T. De La Mare Co., New York. This book contains about 250 pages. On its title page I find the following paragraph: "How to plant and maintain the home grounds, the suburban garden, the city lot, how to grow good vegetables and fruits, how to care for roses and other favorite flowers, hardy plants, trees, shrubs, lawns, porch plants and window boxes, chapters on garden furniture and accessories, with useful rules and recipes, selected lists of plants, etc."

There is an attempt to cover too much gardening in so small a book, and the type is too small for comfortable reference.

"The Backyard Garden," by Edward I. Farrington. Published by Laird & Lee, Chicago, price $1, is one of the best small 200-page garden books. It does not contain as many illustrations as the "Garden Guide," but does cover the essentials of home yard gardening very well. "Home Vegetable Gardening from A-Z," by Adolph Kruhm, published by Doubleday, Page & Co., New York, is very well written, and interestingly illustrated. The one criticism that might be offered is that the frequent references to the Pacific coast lead one to believe the author is more familiar with the west and does not know our conditions as well as some local authority. Still, the book is good and would be of great help to either the beginner or the professional.

"School and Home Gardening" is one of the best garden books I know of for use in the high school as a textbook. It is edited by Kary Cadmus Doois and published by J. B. Lippincott Co.

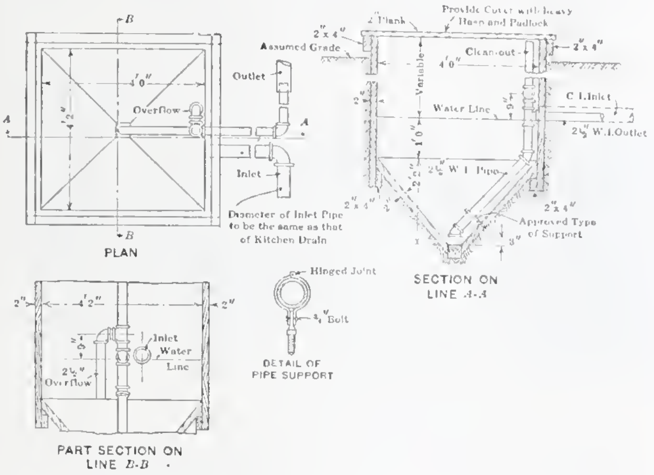
It is the textbook for young people, with plans, suggestions and helps for teachers, clubs, leaders and organizers, and will serve them better than any book I could recommend.

"Practical Gardening," by Hugh Findley, published by D. Appleton & Co., New York, is a book I can highly recommend to every garden fan.

Sewage and Wastes Disposal for the United States Army

A review of the work of the Sanitary Section of the Construction Division of the United States Army is contained in a paper by Leonard S. Doten, M. Am. Soc. C. E., Major, Q. M. C.; officers in charge of Sanitation Section, Engineering Branch, Construction Division, U. S. Army, recently presented before the American Society of Civil Engineers. Information of interest is contained in it. Factors of design, operating results and other information is contained in the following abstract from the May, 1919, Proceedings of the Society.

Collection and Disposal of Garbage and Wastes.—In June and July, 1917, much study was given to the problem of the collection and disposal of garbage and other wastes at the 16 National Army Cantonments. As a result of this, it was decided to classify the wastes and separate the waste materials in such a manner as to secure the best possible returns from their sale.



Standard Grease Trap—Capacity 200 Gal., 250 Men.

The scheme finally adopted consisted in collecting the garbage by the duplicate can system, collecting and transporting all valuable waste materials to a central transfer station, where they were delivered to the contractor.

Incinerators were built at each of the transfer stations, to be used in the destruction of such waste materials as had no commercial value, and also to be used in the case of an emergency when, for any reason, the contractor failed to remove the garbage promptly.

In some instances the contractors disposed of the garbage by means of reduction plants in large near-by municipalities; and in other cases this material was fed to hogs.

The waste materials were classified as follows: Garbage, paper, bottles, tin cans, bones, fat and grease, and manure.

The sale of these materials, rather than their destruction by incineration, has resulted in a large revenue to the Government. For July, August, September, and October, the sales of garbage and other wastes included in the preceding classification amounted to $360,570.

In determining the capacity of an incinerator for a camp, it is assumed that the quantity of material to be handled would be 1 ton per 1,000 men per day, and that 8 hours would be the operating period per day.

The designs provide for ample firing and combustion chambers; a grate surface for natural draft to burn 35 lb. per sq ft. per hour, and for forced draft, 60 lb. per sq. ft. per hour; a drying hearth to facilitate the cremation and to prevent liquids from reaching the grates; dampers to control the draft; and ample stack area and height to prevent back-firing and produce an average velocity of gases of approximately 20 ft. per sec.

New Grease Intercepting Trap.—Although provisions were made for intercepting the grease from kitchen waste-water at the time the original cantonments were constructed, it was found, later, that the commercial type of trap which had been used was not effective, owing partly to faulty design and partly to limited capacity, and, early in 1918, it became evident that a more effective type should be used, in order to prevent the sewer pipe lines from being filled with grease deposits, and to relieve the excessive grease load on the sewage treatment plants.

Traps having a holding capacity of approximately ⅔ gal per capita were designed, and have been placed in nearly all the cantonments. The special features of these traps are: The relatively large area for the collection of grease; the steep-sided pyramidal, or conical, bottoms, and the small diameter of the eduction pipes which remove the settleable solids. The efficiency of these traps has been determined by several series of carefully made tests which show conclusively that the average efficiency under the usual operating conditions is at least 95 per cent, and, in some instances, 99 per cent has been recorded.

Grease recoveries by these traps range from 10 to 25 lb per capita per year. The average is estimated to be between 12 and 14 lb.

Sewerage Detail.—Numerous determinations of the grease content of the sewage have been made at the camps, and indicate that 150 parts per million is a fair average quantity It will be noted that this is very greatly in excess of the quantities usually found in municipal domestic sewage, the average of the latter usually ranging between 20 and 30 parts per million. This is one of the most important characteristics of military camp sewage. The following are fair averages of some of the other constituents of camp sewage:

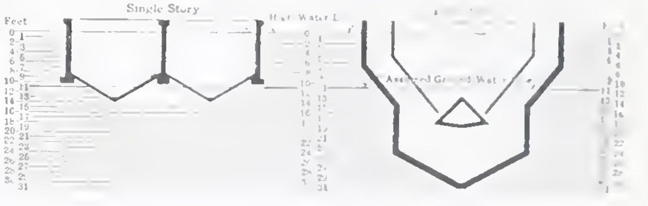
Total organic solids	700 parts per million
Total suspended organic solids	464 parts per million
Free ammonia	18 parts per million
Total organic nitrogen	32 parts per million

It will be seen, therefore, that the sewage is highly concentrated, and that the quantity of suspended organic matter is exceptionally high. The strength of the sewage is undoubtedly largely due to the relatively small per capita water consumption, certain waste products from kitchens, such as garbage and grease, and to the fact that the population is made up wholly of adults.

The sewage flow per capita per day ranges from approximately 35 to 60 gal. In cantonments having a population of approximately 40,000 to 50,000, the maximum diameter for the outfall sewer is usually between 24 and 30 in.

The sewer connections to the lavatory buildings are 6 in. in diameter. In a few instances, the connections for kitchens have been 4 in. in diameter. The specifications adopted by the Construction Division contain a tabulation of minimum gradients, for sewers of different sizes, which will produce self-cleansing velocities. The calculations are based on a mean velocity of approximately 2¼ ft. per second, with the sewer half full or full. All computations for capacities are based on sewers flowing approximately full during the highest rates of discharge.

The specifications require that the average distance between manholes shall be 350 ft. The manholes are of the simplest possible design, and are either square or round. The sides are vertical, except where it is necessary to use standard cast-iron frames and covers. It has been the practice of the office to avoid, as far as practicable, the use of cast-iron frames and covers.



Cross-Sections of Sewage Tanks of Equal Capacity, Showing the Relatively Great Depth of a 2-Story Type as Compared to the Standard Type. The Cost of the Former Tank Is Greatly Increased on Account of Depth Below Ground-Water Line.

Vitrified clay sewer pipes, with the standard type of Portland cement joints, have been used almost wholly. In a few systems, concrete outfall sewer pipe lines have been constructed.

Sewage Treatment Works.—In most cases, the treatment works consist of sewage tanks and chlorinating equipment only. In comparatively few cases has it been necessary to put in secondary treatment works consisting of trickling filters and secondary sedimentation tanks.

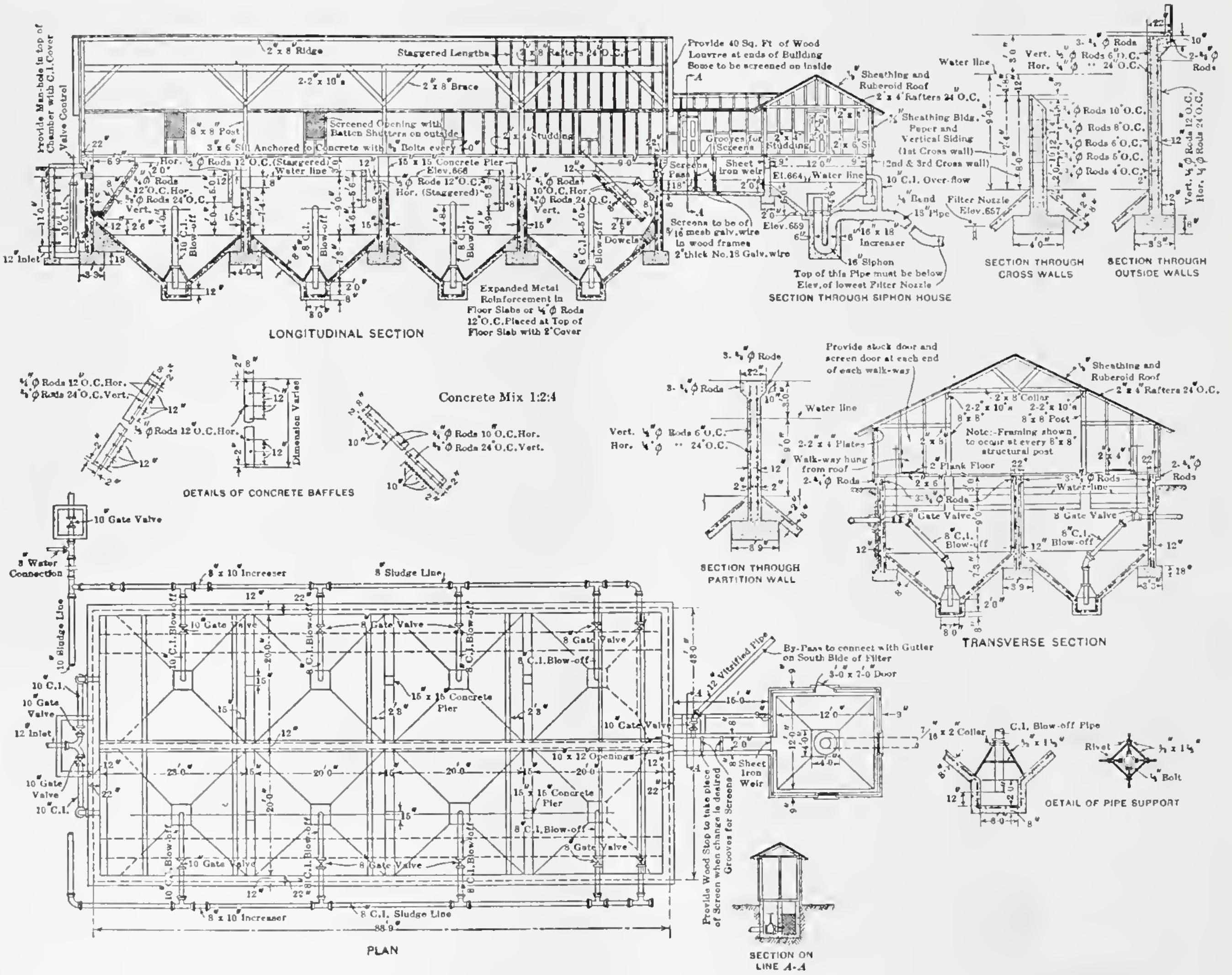
The trickling filter, owing to its large unit capacity, simplicity of operation, and low cost, was adopted as the best means for secondary treatment.

The filter has an undulating floor, the distributor pipes being placed on the summits and pipe-covered gutters in the depressions. Thus the expensive system of under-drains, which is usually an important feature in plans for municipalities, was eliminated. The inverts of the drains and gutters are in a plane parallel to the plane passing through the spray nozzles. This plane has an inclination approximately equal to the hydraulic gradient of the distributing system during the average rate of discharge from the nozzles.

The filtering material consists of hard, durable, crushed rock or slag, the pieces of which will pass a screen of 2½-in. openings and be retained on a screen having 1½-in. openings.

The first filters were 6 ft. deep. In a few plants for hospitals 8-ft. filters were used. The present standard depth for trickling filters is 5 ft.

Dosing or Siphon Chambers.—Siphon chambers were designed with a view to securing the highest possible efficiency in the operation of trickling filters. A radical change has been made in the dosing period, reducing it from 4 or 5 minutes to a maximum of 1½ minutes for filters of all depths. Filters not more than 5 ft. in depth when dosed in this manner will yield a uniformly stable effluent, which is generally very low in turbidity.


LONGITUDINAL SECTION
SECTION THROUGH SIPHON HOUSE
SECTION THROUGH CROSS WALLS
SECTION THROUGH OUTSIDE WALLS
DETAILS OF CONCRETE BAFFLES
Concrete Mix 1:2:4
SECTION THROUGH PARTITION WALL
TRANSVERSE SECTION
DETAIL OF PIPE SUPPORT
PLAN
SECTION ON LINE A-A
Staggered Lengths
2"x 8" Ridge
2"x 8" Brace
8"x 8" Post
Screened Opening with Batten Shutters on outside
Expanded Metal Reinforcement in Floor Slabs or ¼" ϕ Rods 12" O.C. Placed at Top of Floor Slab with 2" Cover
16" Siphon
Top of this Pipe must be below Elev. of lowest Filter Nozzle
Screens to be of ⅜" 16 mesh galv. wire in wood frames 2" thick No. 18 Galv. wire
Provide 40 Sq. Ft. of Wood Louvres at ends of Building Same to be screened on inside
Sheathing and Ruberoid Roof
Water line
12" Inlet
8" Water Connection
10" Gate Valve
8" Sludge Line
8" x 10" Increaser
8" C.I. Sludge Line
10" Sludge Line
15" x 15" Concrete Pier
8" C.I. Blow-off
8" Gate Valve
10" x 12" Openings
12" Vitrified Pipe
By-Pass to connect with Gutter on South Side of Filter
3'-0" x 7'-0" Door
Sheet Iron Weir
Provide Wood Stop to take place of Screen when change is desired. Grooves for Screens
C.I. Blow-off Pipe
Rivet
Bolt
88'-9"

Plan, Section and Details of Type A, Multiple-Stage Sewage Plant.

During a series of tests at the Ft. Meyer, Va., filter the effluent contained: Organic nitrogen, 0.7; free ammonia, 1.8; nitrites, 0.4; nitrates, 25.4 parts per million. The dissolved oxygen averaged 42 per cent of saturation.

Assumptions for Design of Treatment Plants.—The following assumptions are made in the design of all sewage treatment plants: For temporary camps or cantonments, average daily per capita flow of sewage, 60 gal.; hospital plants, 150 gal. per bed per day, and 60 gal. per attendant per day; average detention period in tanks, 6 hours, based on net capacity of tank, making a certain allowance for sludge capacity; maximum dosing period during highest rates of flow, 1½ minutes; filter capacity, 30,000 population per acre, with 5-ft. depth.

Up to the close of 1918, the Construction Division has built 150 tanks of standard design and they have a total holding capacity of 20,000,000 gal. These plants are distributed throughout all parts of the United States. Comparatively few filters have been constructed, the total number being only 19, having a total area of 447,000 sq. ft.

Conclusions Regarding Sewage Treatment Plants and Processes.—The writer's experience leads to certain conclusions relative to sewage treatment plants and processes, which are summarized as follows:

Sewage contains both acid and base-forming constituents. If the base-forming elements predominate, the decomposition of sludge and scum will be rapid. If, on the other hand, the acid products of decomposition are not promptly neutralized, bacterial decomposition will be greatly retarded.

If the water portion of the sewage is high in alkalinity, the bacterial action will be vigorous, and the digestive capacity of a tank correspondingly increased. Co-ordination of certain observed facts relative to the performance of tanks in widely separated parts of the country has confirmed this conclusion.

The color of sludge alone is not a true indicator of thoroughness of digestion, as the sludge in an Imhoff tank may be blackened by the presence of iron sulphide, one of the products of decomposition, and still be incompletely digested. It is true, however, that well-digested sludge is either dark brown or black. Furthermore, the so-called "tarry" odor is not an essential characteristic of thoroughly digested sludge, as the writer has examined many samples which not only did not have an odor of this kind, but were practically odorless, and dried very rapidly, even under adverse conditions.

The effluent from a Construction Division type of tank, when functioning normally, is superior to that of a plain sedimentation tank, due to the fact that the very finely divided matter borne in suspension is partly mineralized.

The capacity of a trickling filter does not vary directly with the volume of filtering material, a 5-ft. filter giving as good results as a deeper one. The average rate of dosing for filters of all depths should not exceed 2,000,000 gal. per acre per day, if a high degree of purification is desired. The short dosing period is of more importance than perfect distribution.

The humus discharged from properly functioning trickling filters should not create an objectionable condition due to putrefaction. The putrescible character of the effluents from some deep trickling filters, and also the humus held in suspension, is due either to an inferior quality of tank effluent or to improper dosing. If the flow from spray nozzles continues too long, the entire depth of filtering material will be drenched, with the result that insufficient time will be given for the thorough oxidation and nitrification of the organic matter. The flow from underdrains should be maintained at as uniform a rate as possible.

Treatment by intermittent sand filters, even in localities where the soil is exceptionally good quality for the purpose, has not been as satisfactory as anticipated, owing to the unusually high grease content in the sewage. It has been necessary, consequently, in certain instances, to put in tanks for the preliminary treatment of the sewage before discharging it on the sand beds. Furthermore, such plants (intermittent sand filters) are usually higher in cost of construction, and considerably more expensive to operate, than those of the standard type.

The wide variations in rates of flow at camp sewage treatment plants, the extremely high suspended organic content of the sewage, and the inhibiting influence on bacterial development resulting from the excessively large quantities of grease, are important factors in determining the load which is borne by the camp sewage tanks. Statistics fail to show that there has ever been any instance where these adverse fundamental factors were so great. This is a fact that should not be overlooked in assigning tanks of this type to their proper place in the sanitary engineering practice of the future.

Average Cost of Food in 1913 and 1918—The following tabulation made public last week by the Bureau of Labor Statistics of the Department of Labor shows the average cost per family per year of 22 principal articles of food for the years 1913 to 1918, and for June, 1919, in 39 cities.

	Average cost per family per year for 22 articles of food in specified cities, based on prices in—			Per cent of increase from 1913 to—	
City	1913 (Average for year)	1918 (Average for year)	June, 1919.	1918.	June, 1919.
Providence	$384.59	$667.71	$707.36	74	84
Boston	392.65	645.62	693.16	64	77
New Haven	381.46	654.15	686.78	71	80
Fall River	379.83	633.40	684.84	67	80
Charleston, S. C.	360.33	600.21	675.65	67	88
Washington	348.66	620.93	670.65	78	92
Manchester	370.24	632.63	669.95	71	81
Birmingham	356.04	594.84	669.32	67	88
Richmond	345.19	598.40	666.59	73	93
Jacksonville	377.73	599.[illegible]4	665.86	59	75
New York	359.48	601.99	662.77	67	84
Atlanta	354.69	600.71	660.39	69	86
Philadelphia	356.80	614.08	659.09	72	85
Pittsburgh	354.74	606.23	654.87	71	85
Scranton	339.69	578.15	654.36	70	93
Dallas	357.62	586.40	652.73	64	83
Newark	368.77	618.26	652.53	68	77
Memphis	340.61	573.10	647.72	68	90
Baltimore	330.01	601.54	641.59	82	94
Little Rock	356.46	586.57	637.53	65	79
Los Angeles	370.71	571.00	630.99	54	70
Cleveland	343.68	571.81	628.85	66	83
Seattle	351.34	576.07	627.24	64	79
New Orleans	340.66	559.27	624.19	64	83
Detroit	324.29	563.24	623.35	74	92
San Francisco	350.97	568.67	623.25	62	78
Louisville	335.58	561.89	622.59	67	86
Buffalo	321.72	570.81	611.36	77	90
Omaha	324.56	548.58	609.45	69	88
Cincinnati	327.04	546.87	608.40	67	86
Kansas City	330.70	555.44	607.49	68	81
Denver	325.69	548.81	604.19	69	86
Salt Lake City	347.60	547.47	603.23	58	74
Portland, Ore.	350.56	559.69	602.31	60	72
Indianapolis	334.66	546.82	596.38	63	78
St. Louis	316.82	549.30	595.46	73	88
Milwaukee	318.03	536.90	591.26	69	86
Chicago	327.92	544.74	582.02	66	77
Minneapolis	311.37	509.73	577.71	64	86

The articles upon which the above costs are based, weighted according to quantity used, are: Sirloin steak, round steak, rib roast, chuck roast, plate boiling beef, pork chops, bacon, ham, hens, fresh milk, butter, cheese, lard, eggs, bread, flour, cornmeal, rice, potatoes, sugar, tea and coffee.

Disadvantages of Locating Water Mains in Alleys

The plan of laying water mains, gas mains, sewers, steam mains, telephone conduits and all other underground structures, used for the service of the public, in the alleys instead of in the streets is frequently advocated and sometimes tried.

C. R. Henderson, manager of the Davenport Water Works Co., Davenport, Iowa, in a paper presented before a recent meeting of the Iowa Section of the American Water Works Association, states that the principal reason given by advocates of the plan is that by laying mains in alleys the streets will be opened less frequently and consequently pavements will be less often disturbed.

The principal objection to the alley is that it is not wide enough to accommodate all the underground work and that alleys, as usually laid out, are not continuous and usually run in one direction only. Gas mains and water mains, but especially water mains, must be laid as a gridiron, crossing frequently at right angles, and this is seldom possible if alleys are used exclusively. Water mains supply fire hydrants which are necessary and are usually, and properly, located at street intersections. As an example: The commercial district of Davenport is covered by a perfect gridiron of good size mains. All the alleys in this district run east and west. If the mains were laid in these alleys the north and south mains would have to be laid in streets. In such case hydrants at street intersections would be on one main only while alley hydrants, which are less numerous, would be near intersecting mains. Hydrants are also required halfway between street intersections on east and west streets as well as north and south streets and if mains were laid in alleys these hydrants would have to be eliminated as there would be no space in which to set them in our 20-ft. alleys.

Gas and water services require shut off cocks and curb boxes for outside control, and these are best located on sidewalks if they are to be accessible when needed. Curb boxes should always be located on public property. When located in alleys heavy vehicles are likely to pass over them and break them. It is not desirable to place a curb box at any point where it may be covered by ash barrels, manure boxes or other material.

When locating a meter in a commercial district the front entrance to a building is superior to the rear entrance in most cases.

In existing residential districts the same objection above mentioned regarding the width of alleys and that they usually run in one direction only, and not continuously, applies. In new additions provisions could be made so long as one policy prevailed, but mains running at right angles to the prevailing direction of the alleys would have to be laid in streets.

When blocks are 500 to 800 ft. between cross streets, sufficient hydrants would not be possible for proper protection, conveniently located, when mains were in alleys.

In two cases the plan of laying water mains in alleys has been tried in new additions in Davenport. In one case, a high class residence district, private rights of way had to be provided for hydrant branches, also for some mains, in order to complete the layout. One 8-in. main in this district now lies very deep under a brick wall and other expensive improvements in the yards of fine houses. The alley was vacated in this case. Parts of the district were platted without alleys and mains were laid in the streets, necessarily.

In another district, houses were built facing, and on each side of a wide boulevard. The water mains were laid in the alleys behind each row of houses. This plan worked all right until houses were built on the far side of one of the next parallel streets when mains had to be provided for them. There being no alley, the main was laid in the street, and we now have parallel mains one-half block apart.

In one Iowa city the principal main was laid through the alleys of the commercial district. Fire hydrants located at the street intersections were supplied from this main by long branches of smaller pipe. These long hydrant branches added to the expense of the system, added to the loss of head between the main and the hydrant, and there being no flow in the pipe between the main and hydrant, the danger of freezing would naturally be greater than in a normal installation.

Extraction of Grease from Dried Activated Sludge

Experimental studies of the extraction of grease from dried activated sludge have been carried on at the University of Illinois as a thesis by D. F. McFarland, under the direction of Edward Bartow. The following matter has been taken from a recently issued bulletin of the Division of the Illinois State Water Survey.

To ascertain the amount of grease extractable from sewage coming from an average residence community and to study the possibility of carrying on the extraction of such grease either at a profit or with notable improvement of the product, experiments were conducted with sludge produced at the State Water Survey experimental plant treating sewage from the city of Champaign by the activated sludge process.

Methods of Extraction.—The methods used in degreasing low grade materials usually involve extraction with either steam or hot water under pressure or percolation with a volatile solvent, cold or hot, and with or without pressure.

For the purpose of laboratory studies to determine the amount and nature of grease extractable, percolation with a volatile solvent offers the most satisfactory and convenient method.

Outline of Investigation.—Information is desired upon the following points:

A. Determination of the amount of grease which can be extracted by different appropriate solvents.

B. Study of optimum conditions of extraction, such as time of extraction, volume of solvent required, losses of solvent, etc.

C. Study of effect of acid in liberating fatty acids from insoluble soaps in the sludge, in improving the physical condition of the sludge and in facilitating its separation.

D. Properties of grease obtained by different methods of treatment.

Extraction Tests.—Solvents. For experimental purposes petroleum ether boiling from 6° — 70° C. was selected as a solvent. On a commercial scale this would have to be replaced by a low boiling naphtha or gasoline.

Some experiments were also made with carbon tetra-chloride and with benzine as solvents, but with unsatisfactory results.

Apparatus. The extractor used was modeled on the principle of a Soxblet extractor and had a capacity of 1 kilogram (2.2 lb.) of dried sludge. A sketch of the apparatus is shown in Fig. 1.

The volatile solvent boiling in a three-liter flask B is condensed in the reflux condenser C and is delivered through tube X into the upper portion of the extraction cell A. This is made of an aspirator bottle and holds 1 kilogram of dried sludge. The solvent rises in the cell in contact with the sludge until its level is above the highest point of the siphon tube Y when it passes through the cloth filter D and the siphon Y into flask B.

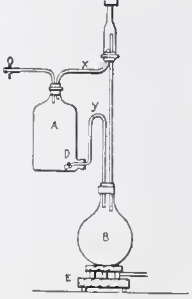


Fig. 1.

When properly adjusted the extractor will run for long periods of time without any attention and with practically no loss of solvent.

After extraction is complete the greater part of the solvent is distilled off and the final traces are removed by heating on a steam bath in an open, tared dish. The dish containing the dry extract is weighed to obtain the weight of grease extracted. One kilogram of dried sludge occupies approximately 90-100 cu. in. of space, depending on size of particles and closeness of package. From 1,500 to 1,800 cc. of solvent is required for the extraction of 1 kilogram of material. This is all recovered excepting about 200 cc. which adheres to the residual sludge after extraction and 100 cc. more which is allowed to remain with the extracted grease and to evaporate spontaneously.

Extractions were carried out as follows:

(a) On untreated dry sludge.

(b) On residues from the first extraction after treatment with varying proportions of sulfuric acid.

(c) On sludge treated with acid before dewatering in the centrifugal separator, and then dried.

(d) On dried sludge treated with dilute acid to acid reaction, and then dried.

(e) On untreated sludge with coarse and fine grinding.

Results and Effect of Variation of Conditions.—The amount of grease extracted from the untreated material varied with different lots of dried sludge from 4.16 to 6.00 per cent. Acid treatment increased the yield to from 5.81 to 8.10 per cent.

The effect of size of particles upon the degree of extraction does not appear to be very great. The highest and the lowest yields were obtained from rather coarsely ground material. The material giving the low result was not exhausted at the end of 22 hours and gave some additional yield with another six hours' extraction. The total result after 28 hours was 4.16 per cent compared with 5.89 per cent from material from the same lot after treatment with acid.

The optimum conditions of treatment and extraction as shown by these experiments appear to be as follows: Treatment with slight excess of acid before dewatering and drying sludge. This assists in separation of colloids, and sets free fatty acids from lime soaps. It also decomposes sulfides and carbonates, and apparently improves the physical condition of the material. Extraction with low-boiling gasoline or petroleum ether for at least eight hours.

Time of extraction. A test to determine the best time of extraction gave results as follows:

In 4 hours, 3.91 per cent or 66.04 per cent of total.
In 8 hours, 5.59 per cent or 94.84 per cent of total.
In 36 hours, 5.89 per cent or 100 per cent of total.

Temperature of solvent. Under the conditions used, the solvent was at room temperature or only a few degrees above it. Use of heated solvent, especially under pressure, might greatly improve the extraction.

Examination of Extracted Grease.—The grease extract obtained from samples which had not been acidified was very dark in color and of disagreeable odor.

The extract from acidified samples was lighter in color and not so unpleasant in odor.

The extract obtained by treatment with acid after a preliminary extraction of unacidified grease was light brown in color and had an odor characteristic of free fatty acids. This contained a high percentage of free fatty acids.

In order to determine the value of the grease for soapmaking or other purposes, the customary analytical determinations of unsaponifiable material, saponification number, iodine number, and acid number were made.

Any portion of the grease which will not react with alkali to form a soap is termed unsaponifiable matter. The amount of this material is therefore an important index of the soapmaking value of the grease. The usual limit for unsaponifiable matter in grease for soap-making is about 5 per cent.

Considerable difficulty was experienced in obtaining satisfactory results on this determination. It was found that the period allowed for saponification by the standard method given by Lewkowitsch was too short, thus giving results entirely too high. In later determinations the saponification was carried out by boiling the mixture of fat and alcoholic potash four or more hours with a reflux condenser. The results gave a much lower percentage of unsaponifiable matter. It is not unlikely that even lower results might be obtained if the saponification were carried out under a higher temperature, under pressure, or using glycerine potash solution instead of alcoholic potash.

Determinations were made upon grease extracted without acid and upon that obtained from acid-treated sludge. As might be expected, the proportion of unsaponifiable matter was somewhat lower in the extract from acid-treated sludge because of the presence of a large proportion of free fatty acids.

According to the averages of the two determinations, which are most reliable, fat extracted from untreated sludge with a total extraction of 6.00 per cent or 120 pounds to the ton, would yield 58.95 per cent saponifiable material, or 70.74 pounds to the ton.

On acid-treated sludge with an extraction of 8 per cent of grease, or 160 pounds to the ton, a yield of 62.78 per cent saponifiable would be obtained, or 100.45 pounds to the ton. At 2 cents per pound the prices obtained would be respectively $1.42 and $2.01.

The saponification number is also an indication of the amount and quality of available soap-making fat in the grease. The untreated sludge had an average saponification number of 126.5. This low number is due to the fact that only about

60 per cent of the material is saponifiable. This indicates that the saponifiable portion would have a saponification value of nearly 200.

The iodine number is an index of the amount of unsaturated compounds in the grease, and shows its probable stability toward oxidation, or its liability to change on exposure.

The iodine numbers of the untreated sludge averaged 43.0.

The acid number is an index of the amount of free fatty acids in the grease as distinguished from fatty acids combined with glycerine in the form of fat. These free fatty acids are fully available for soap making and add to, rather than detract from, the value of the grease used for such purposes.

The acid numbers averaged on the untreated sludge 25.7, on the spent treated sludge 70.9, and on the treated sludge before filtering 41.65.

The extracts from acid-treated sludge show much higher proportions of fatty acids.

From the results of the experiments performed it is evident that the amount of extractable grease in the dried activated sludge is very low, not exceeding 6 per cent of the unacidified dried material. The yield is increased to a maximum of 8 per cent if the sludge is treated with acid either before or after drying.

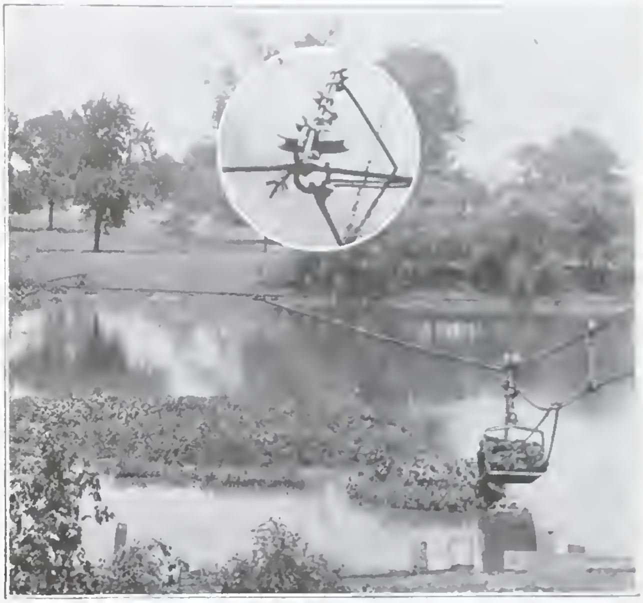
Evaporation in the Canal Zone.—The Weather Bureau of the Department of Agriculture has published an article, "Evaporation in the Canal Zone," by Mr. H. G. Cornthwaite, formerly Chief Hydrographer of The Panama Canal. Some of the salient facts brought out are as follows:

The average annual evaporation from a pan floating on the surface of Gatun Lake is approximately 62 in. The quantity of water lost from the surface of Gatun Lake during the 4 dry-season months is nearly as great as the quantity lost during the 8 months of the rainy season. The greatest daily evaporation loss of record from Gatun Lake is 0.4 in., occurring in March, 1918. Approximately 60 per cent of the evaporation loss occurs during the daytime, 8 a. m. to 8 p. m., and 40 per cent at night. Evaporation records were obtained from selected locations on Gatun Lake, to determine the relative rates of evaporation from the open sections of the lake and along the grass and timber covered margins. One floating pan was anchored well out in the open section of the lake. Another was located in the timber fringe bordering in the south shore and a third was placed in the midst of a grassy marsh. The records were continued for six months during the rainy season, with the following results: Evaporation from open lake, 100 per cent. Evaporation from timber fringe, 72 per cent. Evaporation from grassy marsh, 75 per cent.

Soldier Settlement Bill Before Congress.—The Mondell Bill, carrying a fund of $500,000,000 to provide employment and rural homes for sailors and soldiers, was reported to Congress on Aug. 2.

Deposits at Intake Removed by Dragline Cableway Excavator

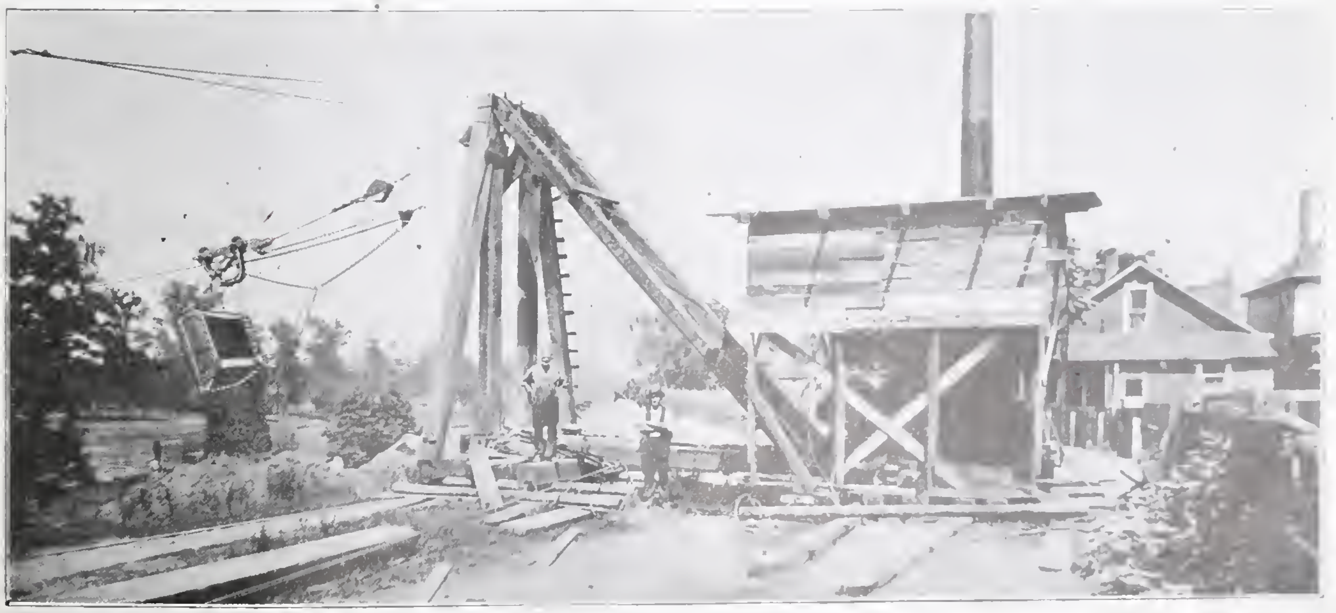
Deposits of silt and mud that had collected around the intake of a power house of the Indianapolis (Ind.) Light & Heat Co. were economically removed by means of a dragline cableway excavator. The power house is located at 18th and Mill St., the water supply being pumped though a 6 ft. concrete conduit. The intake for this conduit is located in Fall Creek near Northwestern Ave., about three city blocks from the power house. A dam across the creek about 200 ft. below the mouth of the intake furnishes an ample supply of water for the power house and also a fine stretch of water for a part of the city park system which extends along Fall Creek on the side opposite the intake.



Method of Attaching Outboard End of Cableway.

The constant flow of water into the intake caused a gradual accumulation of silt and mud to collect in the stream in a semi-circle around the mouth of the intake, seriously obstructing the flow of water into it. This accumulation caused a series of small islands to project above the water about 50 to 75 ft. from the shore and extending close up to the mouth of the intake.

The excavating was done with a Sauerman 1 cu. yd. dragline cableway excavator. The stream is about 300 ft. wide at this point and a narrow street about 35 ft. wide extends along the intake side. A sloping bank between the street



Cableway and Engine Mounted on Portable A-Frame.

and the water's edge offered a good place of deposit for the excavated material. A parkway and boulevard skirt the stream on the opposite side, thus preventing dumping on that side.

On account of the narrow street on the intake side, the cableway and engine were mounted on a self-contained, portable "A" frame. The outboard end of the cableway was anchored to a bridle cable on the opposite bank. As the work progressed the "A" frame was moved along on rollers and the main cable shifted along the bridle cable. The excavated material was held in place by riprap and timbers. The timbers were held in place by cables anchored back into the fill. This fill served to widen the street along the stream and converted a 35-ft. street into a boulevard 75 ft. wide extending along the entire length of the fill.

A foreman, engineer and fireman constituted the entire crew. On account of frequent moves the average yardage excavated was only about 150 cu. yd. per day. When completed about 15,000 cu. yd. of material will have been excavated to an average depth of about 10 ft., leaving a clear and unobstructed flow of water into the intake.

Cost of Electric Thawing of Water Services at New Bedford, Mass.—During January and February, 1918, the Water Department of New Bedford, Mass., thawed 353 services, the total expenditure for the thawing operations being $2,701. The average cost per service, according to the last annual report of R. C. P. Coggeshall, Superintendent of Water Works, was $7.66, itemized as follows:

Electric current	$ .64
Electricians and truck	3.35
Water Department, labor and truck	3.10
Rental of transformer and other stock	.57
	$7.66

The outfit consisted of two trucks each equipped with a 25 kilowatt General Electric transformer, 2,200 volts primary, 110 volts secondary, an ammeter, a single throw knife switch, and a rheostat consisting of an ordinary barrel of salt water, through which the current passes. All of these thawings were made in close proximity to the high tension primary wires of the New Bedford Gas & Electric Lighting Co., which carry a tension of 2,200 volts. In each case they were tapped at the nearest point convenient to the thawing operation. By means of the transformer, the voltage was reduced from the 2,200 on the primary wires to 110 volts on the secondary wires, and the amount of current delivered into the frozen water pipe was further controlled by the salt water rheostat. With these two machines the Department was able to accomplish a maximum of 30 thawings on some days. Time required for thawing each service was from 2 to 190 minutes. The average per service was 17 minutes. Amperage per service varied from 180 to 992. The average per service was 379. K. W. H. used per service varied from 1 to 443. The average per service was 12 plus.

15 Per cent Salary Increase Proposed for St. Louis Municipal Engineers.—That the American Association of Engineers is making progress in establishing more favorable schedules of salaries for engineers in municipal work is indicated by the success of the St. Louis Chapter of the Association in obtaining the support of the Board of Alderman of St. Louis to that Chapter's campaign for higher compensation for engineers employed by the city. A bill introduced before the Board of Aldermen on May 16, 1919, had been approved by the Efficiency Board and endorsed by the Associated Engineering Societies of St. Louis, but had been held in the hands of the Board of Estimate and Apportionment without further action. In order to have the bill called up for action the St. Louis Chapter drafted and had introduced before the Board of Aldermen a resolution requesting the board of Estimate and Apportionment to call up the bill for consideration. As this resolution was adopted unanimously by the Board of Aldermen, and as the Mayor, H. W. Kiel, has announced himself as favoring the bill, it is expected that it will be passed very soon. The bill provides for an increase of about 15 per cent in the salaries of engineers, draftsmen, and related technical men.

The first 3,500-ton concrete ship designed by the Concrete Ship Section of the Emergency Fleet Corporation was launched July 31 at Wilmington, N. C.

Sanitation and Municipal Death Rates*

By GEORGE A. SOPER, Ph.D.†
Major, Sanitary Corps, U. S. Army.

By sanitation is meant that branch of systematic health work which requires plant and a force to maintain it. Examples are works for the procurement and distribution of wholesome drinking water, the collection and disposal of liquid sewage and the gathering and final disposition of kitchen waste, ashes and other discarded material. These are obviously sanitary undertakings but the list of improvements which go to make a city sanitary does not end here. Broad, well paved market places; suitable playgrounds; bright, well ventilated schoolhouses; in short, whatever the city has in the way of plant which goes to prevent the injuries to health which result from too densely segregated masses of people might properly be comprised under the head of sanitation; but in every-day parlance they are not so included.

Sanitation and Disease.—Yielding to works of sanitation are not only typhoid, dysentery, and other diarrheal diseases, but many other forms of sickness. To introduce a public supply of pure water in place of a polluted one, or to build sewerage in a town which has had no good way of disposing of excrement, is to reduce the prevalence of nearly every disease from which men suffer and die. Nothing that can be done is so certain to lessen the death rate.

Sanitary works possess a number of advantages as compared with other measures for the prevention of disease. For one thing, they do not require as high a degree of skill in their administration as do boards of health. For another, they have an advantage over personal precautions in not being individual in application and uncoordinated in action. Sanitary works have a wholesale application. A water supply which is pure is wholesome for every person who has occasion to use it. The street that is well paved and kept clean is of advantage to every one who travels over it by vehicle or foot. And sanitary works do not hide their merits under a bushel. Their good effects are in plain sight—a constant recommendation of the good sense of those who are responsible for the welfare of the community.

The Beginning of Municipal Sanitation.—From the first, sanitation has been a feature of many American cities. Sanitation, although long delayed, when it came, came like a revolution to the continental cities of Europe. The beginnings of municipal sanitation everywhere are due to European initiative. Public water supplies, as we know them today, and sewers to carry away the most offensive and dangerous part of a city's filth, are recent European contrivances. Street lighting, good pavements, adequate transportation, tenement house reforms, the construction of parks and playgrounds, the regulation of vehicular travel and street paving and cleaning have been developed more recently. The American city which ignores foreign practice in these directions fails to take account of experience which can save it a great deal of money.

The sanitary regeneration which European cities have experienced has had no counterpart in the United States. There has been no necessity for such revolutionary changes. American cities were small when the world began to learn that sanitation was an indispensable feature of every municipality. There was never such over-crowding, such slums to clean, such foci of filth to clear up and eliminate, as existed abroad half a century ago. In 1860 there were only 16 cities in the United States with a population of 50,000 or more, as against 148 in Europe.

Municipal Growth in America.—The significant feature of municipal growth in America as compared with that in Europe has been less the reconstruction of cities already large than the construction of a great number of small cities. Hundreds of these have passed and are now passing through their periods of infancy, youth and adolescence toward a maturity which foreign cities attained long ago. Their sanitation takes place as they grow.

The first important sanitary improvement to be made in the growing village is the public water supply. This leads to the use of water closets and, to accommodate the drainage from these, cess-pools are built. The privies, the orginal provision for the disposal of excrement, are then eliminated.

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†From a paper presented at the second Pan-American Commercial Conference, June, 1919.

Street pavements are presently considered and the cleaning of the pavement and the collection of house refuse by municipal effort follow. At first garbage is collected by scavengers at the private expense of the householders; later it is done at public expense. The young city may now be said to have passed through its period of infancy and entered that of youth.

A sewerage system is built later in the city's growth. During this period the houses are gradually built closer to one another and in a more permanent form of construction until they stand in a compact mass. More attention is given now to pavements and to the cleaning of them. Parks are laid out, lighting is improved, ordinances are passed regulating many sanitary matters. The city has now reached its period of adolescence.

The period of maturity, that is, the period in which civic responsibility begins fully to express itself, comes last. The regulation of building construction, the control of traffic and the adoption of farsighted plans to insure public health and safety are often taken up at this time. They should have been considered at a much earlier period.

Business Men First to Appreciate Sanitation as Sound Investment.—It is instructive to observe how often it is that a community owes its sanitary improvements to its business men. It might be supposed that the principles of sanitation were more within the grasp of professional men than of those whose attention was chiefly occupied with manufacture and trade, and that doctors and lawyers and ministers would be foremost to see that the health and welfare of the public were properly looked after. This is not, however, always the fact. There is no disposition to belittle the help which professional men can give, but an experience in public work which covers many years and extends over many cities and states shows that when it comes to municipal improvements, it is the commercial element which usually exercises both the initiating and sustaining influence.

The explanation of this is simple enough. The general subject of sanitation is not so complicated as to be the exclusive province of any class or profession. Certainly the need of sanitation and the benefits of it can be understood by every intelligent person. Business men are accustomed to weigh returns against expenditures and readily appreciate that sanitation is a sound investment. Moreover they are accustomed to action and when they get together to obtain action for the public welfare they are apt to get it.

Often the important thing to know is what to do in order to improve the sanitation of a city. Why is the death rate high? What should be done to reduce it under the particular circumstances which exist? In answering these questions many technical and financial details may have to be considered. This is properly the work of experts. An unprejudiced expert should be called on to make a report based on a study of the local situation and on a knowledge of what other cities have done and are doing under similar circumstances. This report should serve as a program behind which the solid common sense of the municipality can array itself.

When a city needs a health program, as every city does, the best way to get it is for the business men to demand it of the municipal administration through their commercial organizations. If the municipality does not possess the talent for the work, an expert should be called in from outside. In many cases commercial organizations have themselves employed experts to make investigations and reports, to serve as a guide to the citizens in demanding what is proper.

How Much Can a City Afford to Spend for Sanitation?—The question is often asked, what can a city afford to spend for sanitation? The answer is that it can afford to spend whatever is necessary in order to make it healthy. If it is already healthy, it need spend but little; if it is unhealthy, it must, of course, spend more. A city, like a man, must have health, if it is fully to realize its possibilities. Epidemics paralyze business, and a high death rate is a reflection upon the good business sense of a community. In many cases investments for sanitation should be looked upon as policies

Every city and every village ought to have a program of development; a plan to build to, a settled scheme of construction to refer details to. This program should be prepared early, in order to keep the growth properly proportioned, and prevent the excessive development of some relatively unimportant features at the sacrifice of the essential. Paramount in such a scheme should be suitable provisions for health.

Although a considerable investment of capital has to be put into sanitary works, the maintenance charges are not excessive as compared with the administrative costs of hand labor, which is often used as a substitute to accomplish the same result. It must not be expected, however, that good sanitary works can be built or that they can be effectively operated without care. Skill and attention in design and construction and operation are indispensable to the best results.

Among the 219 cities of 30,000 or more population in the United States, for every $10 put out each year for all purposes of administrative effort, $1.10 on the average is expended for health and sanitation. The amount varies among the different cities, according to the natural advantages of the site with reference to water supply, drainage, kind of population and commercial and industrial conditions, and according to the foresight and business ability with which the work is planned and carried out. The percentage of the total yearly expenditure which is devoted to health and sanitation sometimes runs as high as twice the figure stated, and occasionally falls to about one-half of it. The size of the city does not affect the per cent.

The Relation of the Private Well to Typhoid

While state and federal legislation is doing much to suppress the grosser forms of food adulteration, one food, water, by far the most important of all; and which is frequently injuriously adulterated, is not yet commonly considered as coming within the scope of food legislation.

Such are the statements of H. E. Barnard in an address before The Indiana Sanitary and Water Supply Association. He follows with some interesting data on well pollution in Indiana.

The character of the shallow well, whether it is located in a thickly settled community or in the country district, is shown by the thousands of analyses made by health officers in every state. The laboratories of the Indiana State Board of Health have been in operation since 1905. In the more than 13 years we have been analyzing water supplies we have determined with such a degree of accuracy that our statement is not a hypothesis but a fact, that the private well supplies of the state of Indiana are not only to be viewed with suspicion but in rather more than 50 per cent of the cases, definitely polluted.

Of 11,026 private wells examined in the last 13 years, 7,077 have been classified as shallow wells, and 3,949 as deep wells. This classification is not perfect, for it is frequently impossible to get data sufficiently adequate to place a well in its proper class. We classify all dug wells as shallow wells, and all driven wells as shallow wells when it is evident that the well does not pass through an impervious strata. In some parts of the state a layer of clay or hardpan may lie so close to the surface that a driven well not more than 10 ft. deep may in fact reach second water and so entitle it to be classed as a deep well. In other parts of the state, especially where sand and gravel deposits are deep, a well may be 75 or 100 ft. in depth and still tap only surface water. Obviously, when we do not know all the facts our classification is subject to some inaccuracies. Nevertheless, it is significant that of the 7,077 shallow wells used as private supplies but 2,830 were good; that 3,549 were classified as bad and 698 as doubtful. Since a doubtful well water is bound sooner or later to pass the danger line, in the interests of safety it should be viewed with suspicion, and classed with the bad waters. This means that 60.0 per cent of the shallow wells are impure. Of the 3,949 deep wells used as private water supplies, 3,179 furnished pure water, 487 bad water and 283 doubtful water. In other words, more than 80.5 per cent of all the deep wells furnish pure water. The difference in the quality of the deep and shallow well is thus strikingly shown.

There is no real reason why every properly cased well which passes through an impervious strata should not furnish pure water, save in the isolated instances where sewage is poured through sink holes or abandoned gas wells into the lower levels. Such conditions do not obtain in the cavernous regions in the southern part of the state, and they are not unknown in the so-called gas belt

POWER AND PUMPING SECTION

This section of the Waterworks and Hydraulic Monthly issue of Engineering and Contracting is devoted to the selection of power and pumping equipment and the economic management of its operation.

Possibilities of Colloidal Fuel

The Submarine Defense Association, largely through the investigations of its engineer, Mr. Lindon W. Bates, evolved during the war a combination of oil and pulverized coal, which is termed colloidal fuel. An interesting description of the methods of preferring this fuel, its characteristics and operation economies is given in Power Plant Engineering, from which the matter that follows is abstracted.

A feature of the new development is that plants and railroads may buy from the manufacturers any grade of colloidal fuel they desire to the prescription wanted, or they may obtain the appropriate fixated oil and make a final composition themselves. No change in oil-storage or burning equipment is required. Another development is represented by colloidal fuel made with pressure-still residuals which hitherto have been quite neglected.

To make this practicable many months of laboratory research were required to discover a medium which would neutralize gravitation and keep the introduced heavier particles of carbon from settling, and calling for some special apparatus to mill the composite, so that each solid particle is surrounded by a film of liquid hydro-carbon. The new agent is a paste-like greasy substance, called "fixateur." Twenty pounds of this in a ton of liquid fuel keeps the powdered coal and tar suspended in the oil and evenly distributed throughout its volume.

Experiments in making colloidal fuel were conducted at sea on the U.S.S. Gem, a naval research vessel, and on land at a Brooklyn plant of the Standard Oil Co. of New York. No information is given, in a recent report of the association, as to the nature of the fixateur besides saying that it is a heavy, black, pasty substance of the consistency of axle grease. To the amount of 1 per cent of the finished product the fixateur is melted and blended or is placed on the top screen of four horizontal screens which extend through the entire diameter of a tank, about 20 ft. high and 12 ft. diameter. The oil is entered through the top of the tank and seeps through the fixateur. The lower screens catch that part of it which oozes through the first screen, thereby holding it up where more oil can encompass it. When the oil has thus been fixated it is introduced by pumps into the mill, which is a cylindrical tank about 2 ft. high and 3 ft. in diameter, inside of which are the mixers, consisting of arms with balls at the ends. Other forms of ball or tube mills may be used. After the fixated oil and coal dust have been thoroughly compounded, the new mixture is pumped into storage tanks, ready to be pumped through the usual pre-heaters to the burners.

Colloidal fuels may be given the stable life appropriate to the duty desired. Months after mixing the composites showed little or no deposit. Fixateur and fixated oil are readily made and may be shipped anywhere. On burning, the combustion is so complete that with fair coal there is no slag and very little ash left.

Different grades of colloidal fuel for naval, power and industrial use were made and burned in a trial unit.

Characteristics and Advantages of Colloidal Fuel.—These fuels possess unique characteristics and certain advantages shared by no other fuel oils. Heretofore engineers have thought of liquid fuels always as lighter than and floating upon water Colloidal fuels are heavier than water unless the coal content is very small. It is as easy to stabilize 30 per cent to 40 per cent of coal as 5 per cent, and it takes no more fixateur and no different treatment to accomplish.

Colloidal fuels are far safer in storage, whether afloat or ashore because they may be put under a "water seal" of some inches of water or other fire-extinguishing compound which will also arrest evaporation, losses and deterioration. Thus these new liquid fuels not only have a high flash and fire test, but they may be actually "fireproofed" for storage and carriage.

When, during the war, loaded tankers were assailed by gun fire and torpedo fire, when the tanks of oil-burning destroyers or battleships were damaged, they were soon enveloped in hurricanes of fire and ships and survivors struggled in a sea aflame. But with colloidal fuels a blaze in or from one tank would not necessarily involve another. What leaks upon the sea sinks and is thus self-extinguishing. It is especially interesting to note that when poured while blazing upon a water surface 98 per cent of it will sink, or, rather, it all sinks and about 2 per cent rises, occasioning an iridescent film. Among the other favorable points are:

1. An increase in efficiency is obtained, in comparison with lump or mine-run coal burned on grates. This is due principally to the lower percentage of excess air required for combustion and to the fact that there is no loss of combustible in the ash.

2. The flexibility of operation is equal to that of oil, and the equipment may be so arranged that the feed is under perfect control and that sudden demands or overloads can be met.

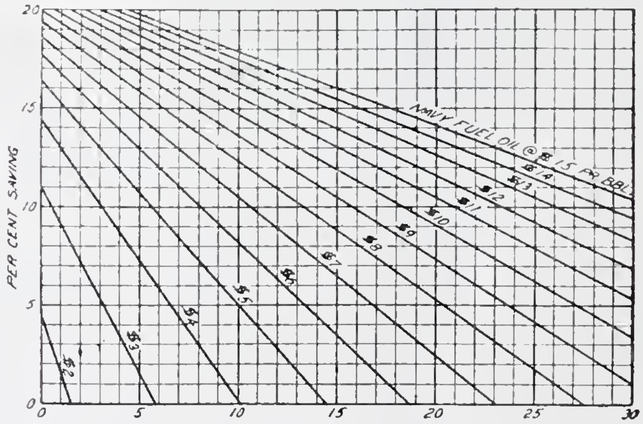

Fig. 1—Diagram Showing Savings With Colloidal Fuel.

3. Lower grades of coal than those now used can be successfully burned. This is one of the true lines of evolution for combating fuel famine.

4. There will be less moisture in the fuel as fired, giving, in comparison with ordinary steam coal, uniform furnace temperature conditions.

5. In case of emergency the firing of the boilers can be stopped immediately.

6. Steam can be made quickly and rapidly.

7. Use on shipboard would quickly simplify the labor situation, already strained. The work of preparing, kindling and maintaining fires, whether the vessel is in port or on voyage, in navy cruising or in battle emergencies, is exacting, exhausting and hard. Reduced labor cost means more mileage, shorter delays and more nearly continuous service.

8. Skilled feed control takes the place of extra arduous labor, so severe that its amelioration is a boon and an uplift to one of the most trying of vocations.

9. Smoke, soot, cinders, sparks, stoking and fire hazards can be virtually eliminated, as can almost all the handling of ashes and the cleaning of fires, ashpans, flues, tubes and smoke boxes.

10. There results more continuous steam pressure, greater sustained boiler capacity, increased boiler efficiency, reduced

cylinder back pressure and more highly superheated steam, as compared with mine-run or lump coal firing. More heat units in the coal are utilized—heat units that would otherwise escape through the stacks.

In marine steaming service the use of colloidal fuel will effect a reduction in units of fuel space per mile run. This will mean with the same tank or bunker space a longer "cruising radius" without refueling, or conversely, that storage can be smaller, and less actual volume of fuel need be carried. Colloidal fuel requires no different equipment from that used to burn fuel oil. The burners need be no larger and are easily kept clear of deposits; there has been no choking of pipes, and storage has presented no difficulties; the coal has remained in suspense for several months, and if sedimentation then begins, a short stirring renews the life of the composite as regards the suspense of carbon particles or the dissolution of a forming jelly.

Regarding the saving of cost involved in the use of this fuel, the report of the association states that, for example, with coal at $4 per ton and oil at $4 per 50-gal. bbl., the saving is $2 per ton. With coal at $5 per ton and oil at $7 per bbl., the saving is close to $6 per ton. A chart developed by Mr. Bates, Fig. 1, shows the per cent savings in cost of colloidal fuel over regular oil fuel for equal heat values.

Different grades of coal have been experimented with, ranging in ash content up to 25 per cent. An especially good carbon material has proved to be a coke containing, it is stated, 98 per cent carbon, no ash and no sulphur. The mobile paste, which is about half oil and half coal, is said to develop the largest number of heat units per unit volume which may be readily pumped to the combustion chamber. As a liquid the percentage of coal should be under 40 per cent by weight.

Meters and Measuring Devices for the Boiler Room*

The principle of the CO_2 recorder is excellent in that it gives a direct measure of the amount of air required to utilize the utmost heat value of the fuel, and gives, therefore an indication of the most efficient combustion. But good over-all efficiency does not necessarily follow from good combustion efficiency, since it is affected by the condition of the surfaces of the boiler, and as an indication of this condition, it is necessary to use a flue thermometer in conjunction with the CO_2 recorder. A temperature standard may then be obtained at different ratings by a test upon a clean boiler using proper combustion, and by reference to this in subsequent operation the flue temperature will indicate when the boiler in dirty. A steam flow meter then also becomes a necessary part of the outfit.

The same functions which are performed by the CO_2 recorder in conjunction with the flue gas thermometer and steam flow meter can be performed by other reliable means, as will be explained. While maintaining the maximum efficiency, a definite amount of combustible must be consumed to produce a definite output for the boiler and to consume this combustible will require a definite amount of air. If the relationship between the amount of air and the boiler output is determined once for all when the boiler is clean and operated at maximum efficiency, this relationship will subsequently serve as a standard by which to operate the boiler. The output of the boiler at any particular moment is proportional to the steam output, provided the feed water temperature is maintained constant and the rate of feed to the boiler is maintained proportional to the steam output.

In holding operation to the standard relationship, account must be taken of the condition of the boiler surfaces. If the surfaces are dirty, the gases must be hotter, so that the water may obtain the same transfer of heat through the tubes, and this will require more coal. There is then an increased amount of coal for the same output, and if the relationship of air to steam is held according to the standard, there will be insufficient air for the increased combustion. There is then a falling off in over-all efficiency, chargeable to these two sources: the inefficient heat transfer to the boiler and the inefficient burning of the coal. But the flue thermometer may be used to indicate this condition. The higher temperature of the gases will be evident in the flues, and by comparison with the temperature known as standard for efficient operation at equivalent rating, the condition of the tubes is indicated

It would seem that this method of operating the boiler depends upon keeping the boilers clean; however the transfer of heat through the boiler is as much a part of the elements operating toward efficiency of the unit as is the proper combustion, and requires attention to that end.

To accomplish the purposes described, many methods have been devised for measuring the air passing through the boiler. In some cases it has been determined by means of pitot tubes, in some cases by orifices in the pass to the air chamber, and in others by using the boiler setting as an orifice.

When the latter method is used, the orifice becomes smaller as the gas passages grow dirty, and the differential indication given by the boiler-orifice is too high as a measure for the actual amount of air. The fireman then reduces the draft in order to maintain the standard ratios of air to steam, and this condition augments the condition of insufficient supply of air caused by dirty heating surfaces, which has been previously explained.

The principal causes of the decrease of the size of the orifice is the formation of slag on the lower rows of tubes in the first pass, and in order to overcome the change in orifice where slag forms, it has been found necessary to place the draft pipe for the differential actuation above several rows of tubes in the first pass of the boiler. It is a question whether or not this is advisable; whether it would not be better to leave the draft pipe below the lower rows of tubes and to instruct the fireman to run in his bar and to break off the slag when the temperature appears too high for the amount of steam produced, thus bringing the orifice back to the normal condition as well as making his boiler more efficient and of undiminished capacity.

If the draft in the fire box is too great there will be a tendency to blow through the doors when opened, and the maintenance expense of the fire brick and grates will be increased, and if the draft is too low the tendency will be toward a vacuum in the furnace and infiltration will be accentuated. Holding about 1/10-in. water draft in the fire box on forced draft stokers has been found advisable for these reasons. Where this is adhered to, and where the coal burned and the design of the furnaces are such that no slag forms on the tubes, the draft in the last pass can be used as a direct measure of the amount of air passing through the furnace, eliminating the necessity for a differential pressure measurement.

The method utilizing steam flow and air flow meters and flue thermometers offers a most promising solution to the question of boiler operation at the present time. If it is perfected to a great degree, it will develop the principle of the remote control of boilers. We are entering into a period when one man will operate all the boilers from a central point.

Another instrument universally used is the tachometer, which gives the speed of the stoker. This may be graduated in various ways to give seconds per revolution, coal per hour or inches of air to be maintained in fire box corresponding to the speed. With the provisions for measuring the amount of coal fed to the furnace, the amount of steam produced and the efficiency of combustion of the coal, the over-all efficiency is at all times indicated or recorded as the case may be, and the fire is completely and properly under control.

Some attempts have been made to indicate or record on one instrument the various conditions which have been described and which have a co-relation with one another to efficient operation, in order to avoid the use of several charts for interpretation, and considerable success is being experienced along this line.

The steam flow meter has progressed greatly since the last report of this committee, and its accuracy as now designed can easily be maintained within 2 per cent.

These meters then may be depended upon for a perfect indication in the boiler room, and also may be used in many cases for the sale of steam.

There are two principles used in the measurement of steam by the best known steam flow meters. One is based upon the orifice method and the other upon the pitot tube. Both of these are accurate in results. The pitot tube has one disadvantage over the orifice: If there is a foreign material being carried along in the steam, it is apt to clog the openings and cause the meter to read in error; however, where there is no danger from this element the pitot tube is just as accurate and reliable as the other.

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*From the report of Committee on Prime Movers, presented at the 42nd convention of the National Electrical Light Association, May 19-22, 1919.

It might be well to point out here to the users of steam flow meters who have had trouble with the clogging of pitot tubes that this form of meter could be easily and inexpensively changed over to the orifice type of meter, and the change would be readily made by any meter concern. This change, however, should be made by someone who thoroughly understands the characteristics of the flow of steam through an orifice, in order that the connections for measuring the differential pressure can be made in the right way and inaccuracy on this account avoided.

Coming now to a discussion of the over-all efficiency of the boiler plant, the instruments used have progressed in proportion with those used for individual boiler operation. Very suitable meters have been designed for measuring the feed water supplied to the boiler. Also meters for measuring the water that is drawn from the boiler in the form of blown-down. Furthermore, recording automatic scales have been developed for recording the weight of coal passing over belt conveyors or through hoppers, so that it is possible to run continuous over-all boiler room tests.

Automatic instruments for measuring coal, however, have not reached the stage of perfection which could be desired, as in order to keep them reasonably accurate they must be continually adjusted. For this reason many plants equipped with the modern boiler of increased size are using the coal larry with the well-known platform scales.

Recording thermometers are coming into more extensive use in various parts of the plant. The installation of economizers calls for the employment of these, and they have proved accurate and essential for efficient operation at this point. As a matter of fact, regarding all turbine and boiler room instruments, the recording type is becoming popular and shows good results from the point of view of decreased cost ot operation of the plant.

The meters used for measuring the feed water may be divided into different classes, one which employs the principle of the V-notch weir, another the principle of the orifice and another the principle of the pitot tube, and there are also meters depending upon weighing devices and volumetric meters.

The pitot tube has the same faults in measuring water that it has in measuring steam, and for this reason it is practically eliminated from this class of service.

The orifice type of meter, which includes the Venturi type, is an accurate means for measuring hot water, and is extensively used. The V-notch weir, which has greatly advanced in recent years, is pressing the Venturi meter for a place in this field, and its accuracy and practicability have become unquestioned. These types may also be used for measuring the water which is taken from the boiler in the form of blow-down. All three of these types of meters with very little attention can be kept well within the accuracy of 2 per cent.

The station load indicator has a place in every boiler room and turbine room. This is sometimes of the taxi-call type, but many plants have devices of their own design.

Indications for special purposes in various plants are of value. It is noted that thermometers have been used on super-heaters where there is trouble from priming of the boilers, in order to give an indication of this trouble. Water back alarm thermometers are used by some. Damper position indicators find some use.

Turbine room instruments have also made considerable advance. We need say nothing in regard to the thermometers, steam gages, speed indicators, etc., which have already become so common, but with the improvement which has taken place in the steam flow meter it has become more and more desirable to equip each unit with a steam flow meter, and by this means an accurate account may be kept of the disposition of the steam produced and a reliable indication given of any trouble which has developed or is developing in a particular piece of apparatus as shown by the increased steam consumption.

Among special devices used in the turbine room, mention should be given to the air bell in connection with condensers as a measure for leakage.

Mention should also be made of the two pen recording thermometer used on jet condensers in certain cases, showing exhaust steam and circulating water discharge temperatures.

Economies in the Boiler Room

Useful suggestions on firing coal in furnaces are given as follows in a recent circular of the Illinois Fuel Administration: During the war there were several agencies which advocated economies in the boiler room in order to allow more fuel to be diverted to the war industries. Effecting these economies is just as essential now on account of the continued high cost of coal and the scarcity of good coal. One of the greatest economies can be effected in firing by keeping a uniform fuel bed at all times. The time to replenish the fire by adding coal is when the fuel bed has burned down below the normal standard and not after the steam pressure falls.

In using mine-run or lump coal the lumps should be well broken up. With screenings or the fine portion of mine run the coal will cake, and these caked masses should be carefully broken, on the top, after the cake has formed. This should be done with a light rake, but the fire should not be stirred or poked. The coal should be evenly spread over all the surface of the fire, giving special attention to the side and corners and always maintaining a good strong, hot fire. While a good fire bed should be maintained, care should be taken that it does not get too thick.

A good strong fire may make too much steam if the draft is strong. Therefore draft dampers on each boiler should be adjusted as often as necessary to keep the fire in the proper state. The steam pressure should be controlled by the draft, because the speed at which the fire burns or at which the heat is produced is dependent upon the amount of opening given the damper.

When fires are banked at night the draft should be cut off so that the bank will lie without burning. In the winter time, when steam is needed for heating, the same kind of fire should be maintained as in the day time, and the draft should be controlled in the same manner as during the day.

Experience with Submerged Coal Storage

In 1912 the Indianapolis (Ind.) Light & Heat Co. constructed at its Mill Street station a concrete pit 300 ft. long, 100 ft. wide and 20 ft. deep, designed to contain 13,000 tons of coal submerged. Recently the company constructed at its Kentucky Avenue station a reinforced-concrete coal pit which is 145 ft. long, 65 ft. wide and 32 ft. deep, built on the same general lines as the former pit and holding 8,000 tons. The company burns 500 tons of coal per day, and as the two pits have a total capacity of 20,000 tons submerged and 10,000 tons of coal above the water line, this means a sixty-day supply on hand if both pits are filled. The total cost of the two pits was $60,000, or $2 per ton of storage, states the Electrical World.

The results of under-water storage, according to T. N. Wynne, superintendent of power, have fully met the company's expectations in that it prevented fires and preserved the heating value of the coal. No trouble has been experienced with excessive moisture when burning pit coal if mine run is used. Screenings which have been stored under water burn with difficulty. Whenever coal from the pit is to be used on the stokers it is loaded into railroad cars and the water is allowed to drain off for about six hours before the coal is put into the bunker. The coal may also be drained by lowering the water in the pit sufficiently to uncover the coal required. It has been found in storing the coal that capillary attraction will take care of coal piled above the water level of the pit as much as 8 ft. or 10 ft. Coal stored for a year under water lost during storage only 317 B.t.u. out of 12,518 B.t.u., or 2.5 per cent.

Method of Stopping Leaks in Reinforced Concrete Reservoir.—The following method of stopping leakage in a reinforced concrete reservoir has been employed with good success by Mr. D. A. Reed, manager Water and Light Department of Duluth, Minn.: If the leaks are caused by cracks a very successful way of removing the trouble is to chisel out the cracks with a ½-in. chisel, making a groove ½ in. in width and about ¾ in. in depth, and caulking with hemp and asphalt. If the leaks are caused by porosity of the concrete, lean concrete, good results can be obtained by the use of some of the various coatings.

MANAGEMENT AND OFFICE SYSTEM

This section is published twice a month: (1) In the Waterworks and Hydraulic Monthly issue, and (2) in the Railway and Excavation Monthly issue. It covers what may be broadly termed "management engineering" as applied in the civil engineering and construction fields.

Advantages of Classified Cash Book in Waterworks Accounting*

By ALBERT L. SAWYER,
Water Registrar, Haverhill, Mass.

Haverhill was the first city in the East to adopt the commission form of government, and we are one of the very few cities that has adopted modern charters where the water board was continued without change as a part of the municipal machine; a condition which I believe is correct and makes for greater efficiency. Under the act of 1891, creating the water department, it was provided that it be entirely separate from the other departments; hence we collect our water rates, handle the money and pay our own bills; the money being spent by the water board with certain limitations provided in the legislative act.

I had worked with the former registrar for a good many years and on succeeding him I kept on the bookkeeping in much the same way that he had handled it. We had a sheet of foolscap ruled off by hand, on which we entered our daily receipts as taken in. At the close of the day these were copied into an ordinary sized cash-book ruled with five columns. At times when business was good, we used to balance this cash-book daily; and at less frequent intervals during other seasons. We would perhaps strike balances eight or nine times a month. We also used what we called a classified cash-book, and in this the receipts were summarized covering the same number of days as the smaller cash-book. All payments were entered as in the smaller one, but many items had to be entered in a sundry column and had to be picked out for the monthly report and to charge in the ledger.

Our new charter provided that the accounts of the city should be audited by a competent accountant (this in addition to the audit by the city auditor), and 4 years ago this work was given to the Bureau of Statistics, who have done the work each year since. The statute under which this bureau makes audits of municipal accounts places the initiative entirely with the cities and towns. As in all matters of this kind, the Bureau thinks that its system is the only one, and they propose a hundred and one things that make for more books and more expenditure of time and money. On the other hand, they have furnished me with some very practical ideas which I think have helped in a more intelligent classification of our accounts. The auditor at once said to me, "You are spending all your time copying over lists of names that serve no good purpose and make for errors, get one cash-book ruled to carry most of your accounts, take a balance each day, but actually balance the cash-book only at the end of the month. You will thus save all this duplication, and your footings will show at once what each subdivision has taken in or expended for the month." The suggestion looked good to me, and I planned out my present cash-book and have used it since, and find it highly satisfactory, and look back with sorrow on the time wasted through 16 years.

The pages of the debit side of the cash book are yellow and take about 50 entries to a page, both sides of the page being used. Those of the credit side are of white paper, printed on but one side, and at the close of the month these are bound in the cash-book following the debit sheets. We have a stub covering every receipt, and these are entered in the cash-book at the close of each day; the cash is balanced daily and the result entered in a small book also suggested by the Bureau of Statistics. The debit side (Fig 1) keeps the receipts from water all at the left, with the amounts of the bill in the first column; then abatements, discounts, and the amount of cash actually received entered in the column where it belong. These five columns added together must agree with the total assessment column. The other receipts are entered in the columns set aside for them.

For the credit side (Fig. 2) I tried to arrange a cash-book that would clearly separate construction and maintenance accounts, giving so far as possible a column to each account; using similarly itemized vouchers for payments and a "distribution-book," such as is used by our city auditor, in which to enter the various items at the end of the month, the whole scheme having in view the annual report at the end of the year. This report has exactly the same subdivisions as cash-book, vouchers, and distribution-book, so that the making up of the financial part of the report takes only so long as it takes to add and verify the footings of the distribution book. Our cash book is loose leaf and, while I arrange it for my own needs, I utilize many valuable suggestions of the Bureau of Statistics. The binder is known as the Kalamazoo, which I would highly recommend as easy to handle, and especially

HAVERHILL WATER WORKS									RECEIPTS									
Date	NAME	Total Assessment	Abatements	Discount	Meters	Haverhill Fixtures	Bradford Fixtures	Other Years	Services	Bldg. Pur.	Rents	Interest	Real Est.	Iron Pipe and Specials	Old Material	Sundries		Cash on hand

Fig. 1.—Debit Side of Cash Book.

HAVERHILL WATER WORKS									PAYMENTS										
					CONSTRUCTION				GENERAL MAINTENANCE										
Date of Bill	To WHOM	Ledger Page	Voucher No.	Amt.	Mains	Services	Meter	Spec. Const.	Mtce.	Current Ex.	Stable	Kenoza Pump Sta.	Millvale Pump Sta.	Bradford Pump Sta.	Meter Mtce.	Crystal Lake Mtce.	Real Est. Mtce.	Sundries	Cash on Hand

Fig. 2.—Credit Side of Cash Book.

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*Abstract of a paper presented before the New England Waterworks Association.

ALBERT L. SAWYER, WATER REGISTRAR.
In account with Haverhill Water Works.

Dr.		Cr.	
Unpaid bills November 30, 1914	$ 2,905.40	By Cash Receipts	$158,225.84
Water Assessment	178,127.19	By Abatements (water)	3,582.55
Labor bills	19,502.71	By Abatements (services)	110.83
Rents	1,209.08	By Discounts	42,487.08
Interest	918.25	By Unpaid Bills (water)	75.69
Town of Groveland	1,126.00	By Unpaid Bills (services)	1,942.71
Sale of wood	2,303.87	By Unpaid Bills (rents)	13.00
Miscellaneous	344.30		
	$206,436.70		$206,436.70

Fig. 4.

as doing away with the post, which to my mind is a great drawback to most loose-leaf systems. This binder, made of pigskin, stands hard usage and we use it not only for the cash book, but for the register of water takers. A desk pad that just holds the loose cash sheets is used for the daily entries and is most convenient, the sheets being bound in the cash book at the end of the month or oftener, if necessary. The advantages as I have found them are:

1. Each receipt and expenditure entered in detail.
2. The items classified as entered.
3. A compact book with no wasted pages.

One of the first things I did after taking charge of the office was to introduce a voucher system. As I said before, we pay our own bills, and these are never sent out of the office with the check, but instead, the voucher (Fig. 3), containing the items of the bills paid, together with a receipt on the one side, and on the other, subdivisions of construction and maintenance, each subdivision itemized as it will later appear in the annual report. As the bills come in, they are checked and classified and the division of the plant to which they are to be charged is stamped on the upper right-hand corner of the bill. When paid, the voucher number is added and the number is also entered on the stub of the checkbook. We are never troubled with lost bills; the vouchers all come back, and the city auditor tells me that it has reduced the time used in checking up the payments in a manner that is satisfactory to him. I regret to add that the Bureau of Statistics does not wholly approve. First, it thinks the city treasurer should pay the bills; second, it favors a voucher check. I hang to my voucher system, but keep my canceled checks well arranged for emergencies. At the end of the month, after our cash-book is balanced, the clerk goes through the vouchers for the month, bringing together in a book all similar items. These are then entered in our distribution-book. As I said before, our annual report follows the same plan and is simply a summary of the distribution book.

Voucher No. *287* Amt. *$31.50*
HAVERHILL WATER WORKS

CONSTRUCTION		
(Main)		
Iron Pipe and Specials		
Gates and Gate Boxes		
Lead, Packing, etc.		
Freight and Cartage		
Pay Rolls		
Sundries		
(Services)		
W. I. and Lead Pipe		
Valves and Boxes		
Oil, Gas, Wood, etc.		
Freight and Cartage		
Pay Rolls		
Sundries		
(Meters)		
New Meters and Fittings		
Pay Rolls		
Freight and Cartage		
(Special Construction)		
(Land Account)		
GENERAL MAINTENANCE		
(Repairs on Mains: Tools: Maintenance)		
Fuel, Oil, Salt, etc.		
Pay Roll, Maintenance		
Pay Roll, Maintenance M. P.		
Pay Roll		
Tools and Repairs	*7*	*10*
Repair Material, etc.		
Sundries		
(Current Expense Account)		
Salaries and Clerical Hire		
Stationery, Printing, Postage, etc.		
Telephone		
Lighting		
Rent and Care of Rooms		
Office Furnishings and Fixtures		
Sundries		
(Stable Account)		
Hay and Grain		
Horse Shoeing		
Horse Hire		
Rent		
Automobile		
Sundries		

(Kenoza Pumping Station)		
Salaries		
Extra Labor		
Fuel and Cartage		
Telephone		
Repairs and Tools	*3*	*50*
Freight and Express		
Oil and Supplies		
Sundries		
(Millvale Pumping Station)		
Salaries		
Extra Labor		
Fuel and Cartage		
Telephone		
Repairs and Tools		
Freight and Express		
Lighting		
Oil and Supplies		
Expense of House		
Sundries		
(Bradford Pumping Station)		
Salaries		
Extra Labor		
Fuel and Cartage		
Telephone		
Repairs and Tools	*8*	*40*
Freight and Express		
Oil and Supplies		
Expense of House		
Sundries		
(Real Estate Maintenance)		
Pay Roll		
Repairs		
(Meter Maintenance)		
Reading		
Repair		
Express		
Crystal Lake Mtce		
Kenoza Lake Mtce		
Round Pond Mtce		
Lake Saltonstall Mtce		
Johnson Pond Mtce	*12*	*50*
Chadwick Pond Mtce		
Reservoir		

Fig. 3.—Voucher.

Haverhill Water Works, Haverhill, Mass.

To Fred F. Spinney, Dr.
Address, Boston, Mass. Voucher No. 287

1916 Date		Items	Amount	
July	17	Bill rendered	$31	50

$ 31.50 Dated........................

Received from the HAVERHILL WATER WORKS the sum of Thirty-one and 50/100 Dollars, in full for the above account.

Signature....................

Per....................

Please Date, Sign and Return this Voucher at once in Enclosed Envelope without Refolding.

Fig. 3.—Reverse Side of Voucher.

In our ledger we carry the usual accounts of mains, services, etc., posting from the cash-book footings at the end of the month. One other thing that the Bureau of Statistics called to my attention was what they call, I believe, a "master account." Previous to adopting this account I regret to say that we simply recorded our receipts, kept track of our unpaid water bills, and trusted we were getting all that belonged to us, but with no exact knowledge as to whether the yearly assessment was accounted for or not.

I now start the financial year charged with so much in unpaid bills of various kinds; I then charge myself with the assessment for meters, fixtures, labor bills, and other bills sent out (Fig. 4). I am credited with abatements, discounts, and cash receipts; and these with the unpaid bills must total the same as the debit side. We take a test balance each month except at water-bill time, when we have to take up two months at once, and if we don't come out right, we have to dig till the mistake is found.

So many errors will creep it, one sometimes balancing another, that I believe this is a most accurate way of keeping things straight. We have had to go over thousands of stubs at times to find an error, but it is certainly a satisfaction to know that every cent is accounted for, while the fact that it must come right, and that errors must be found, is an incentive to the office clerks to be accurate.

Water for Omaha Swimming Pool Purified by Ozonization Process.—An ozonizing plant for sterilizing the water at the swimming pool at Krug Park, Omaha, Neb., was placed in operation on July 3. This pool, said to be the largest and most modern in America, contains over 1,000,000 gal. of water, and has accommodations for 20,000 bathers per day. It has bath house facilities for 4,000 persons at one time. A complete change of water is made every 12 hours. The ozone plant, which was installed by the Ozone Co. of America, Milwaukee, Wis., has a capacity of 2,000,000 gal. per day. This pool was described on page 506 of our May 14 issue.

Labor Turnover and Industrial Training

An annual saving of at least $1,250,000,000 would be made if the manufacturing industries of the United States could wholly obviate labor turnover. This estimate is given in a bulletin issued by the U. S. Training Service, which goes on to say:

Frank A. Vanderlip, president of the National City Bank of New York, and former Assistant Secretary of the Treasury, calculates the preventable labor turnover at from two and one-half to five billions of dollars, but the lesser estimate is preferred because it is unquestionably a conservative statement of the facts. This immense charge—only one of many—it should be remembered, must be met before these enterprises can begin to figure profits. It is facing them in every season, under every condition, in times of prosperity, in periods of depression. It is, indeed, a remarkable circumstance that even in the midst of industrial recession, this burden on business is relatively nearly as heavy as it is during the greatest activity.

Cost of Hiring and Firing.—Perfectly trustworthy statistics put the total number of workers in our American manufacturing industries at about 10,000,000—considerably more than the entire population of Canada. Mangus W. Alexander declares that the hiring of a man in this country runs between $10 and $200. The average, Mr. Alexander tells us, is above $50. Labor turnover in the United States at large and in all kinds and classes of industry is now perhaps 250 per cent. With these facts before us—the number of workers engaged in manufacturing enterprises, the cost of hiring an employe, and the rate of labor turnover—the rest is a computation in simple arithmetic. On a basis of even $50 for every hiring (less than the average stated by Mr. Alexander), as the expense of obtaining a new employe, the calculation will show that every year our manufacturers must count on an outlay of more than a billion dollars.

Turnover Not Wholly Fault of Workers.—It may be convenient to ascribe this excessive and burdensome labor turnover entirely to the restlessness, instability, or perversity of the workers. That is certainly a handy explanation, but it has one rather serious defect—it is not accurate. The physician who begins the treatment of a patient with an improper diagnosis of the disease may have to be set right by an autopsy, and that is painful to all concerned. The truth is that labor turnover is not wholly or even largely the fault of the workers. Most of the blame is the employer's own. That is not a pleasant statement of the case, we know, but it is a correct diagnosis, and that is what is prerequisite to an application of remedies.

In locating the responsibility for turnover we are relying not upon mere theory or speculation, but upon facts, and facts make a very solid foundation. Only recently the causes of discharge in one of our big manufacturing establishments were submitted to a close, scientific scrutiny. The records under examination and analysis were of course the employer's, and there was no question of their completeness, frankness, or want of partiality to the workers affected. This study showed that just 10 per cent of these discharges—a large number all together—were due to slacking on the part of the employes. The other 90 per cent were attributable to shortcomings and defects of one kind or another in the management of the plant. An analysis of the quittances revealed the same conditions—the employer who at fault in 90, and the workers in only 10 per cent of the total.

Causes of Labor Turnover.—The larger share of the blame for labor turnover is incurred by the employer because, having control of the conditions governing production, he nevertheless fails to exercise it in his own interest. Even casual inquiry in the ordinary factory discloses that workers are assigned to tasks for which they are not fitted, and in which they will become skilled, it is fatuously believed, by mere repetition of their mistakes. They blunder along until they have spoiled tools or scrapped materials, or done some damage that in their employer's mind warrants their discharge, unless meantime they save him the trouble by quitting out of sheer dissatisfaction. Others take their places and the process of attempting to fit a square peg in a round hole is repeated indefinitely. The result of this haphazard procedure to the employe may sometimes be discharge and sometimes quittance, but to the employer it is always the same the expense of a new hiring, the spoilage of more material, the breaking of tools and machines, the hampering of output the impairment of profits Labor turnover is, then, not merely a monetary loss in itself, but it is also the occasion of much damage, waste, delay, disorganization, and inefficiency

Industrial Training Reduces the Turnover. There is no remedy that will prevent labor turnover, but it can be reduced, has been reduced, and is now being reduced by many big employers. If labor turnover in the manufacturing industries of the United States were cut in half it would be equivalent to adding more than half a billion dollars a year to their profits. There is a powerful incentive to rid our factories of a big obstacle to production. In a relatively few plants labor turnover has been lessened 50 per cent. Industrial training is the means by which some of our biggest manufacturers are simultaneously minimizing labor turnover and lowering the cost and increasing the volume of production. Two of these corporations are among the greatest of their kind in the world. Jointly they employ 10,000 persons. Altogether, there are 200 American manufacturers who have adopted industrial training as an integral part of their scheme of production.

Industrial workers are entitled to training. But even if they were not it is to the employer's advantage to give it to them. Inefficiency in production is traceable to causes which, for the most part, training of the worker—and concomitant training of the management—would remove. It fosters teamwork and contentment; serves as a testing laboratory, so to speak, in which to determine the degree of skill and experience possessed by applicants for employment before they are regularly assigned to the shop floor; it reduces waste and damage; it gives the worker a better opportunity and a greater incentive to improve his position and prospects, and affords the employer a large scope in selecting men for promotion.

Reasons for Low Efficiency Labor.—Six general reasons are assigned for low efficiency. They are (1) power failure; (2) failures of equipment and repairs; (3) lack of instructions; (4) lack of training; (5) failure to supply material; (6) personal slacking. It will be seen that every one of these factors contributes directly or indirectly to labor turnover—that onerous charge against production. Failures of power, of equipment and repairs, of materials, of instruction—all these eventuate in discharges and quittances, hirings and rehirings. It need hardly be said that industrial training which discovered and corrected these faults of management, instructed the worker in his duties, broadened his craftsmanship, and enlarged his versatility would diminish turnover while concurrently it decreased the cost and enhanced the rate of output.

To establish a system of adequate training in a plant or factory presupposes a survey that uncovers the causes and extent of labor turnover, the obstacles to output, sources of delay, reasons for scrap work, and all the other conditions that make for low production. Where such surveys and analyses have been made by experts of the United States Training Service and training has been adopted, turnover has been lessened, and the rate of production accelerated. "Not knowing how to do the job" has two results: First, low efficiency, and second, quittance or discharge—labor turnover. Each of these operates to increase the high cost of production Both the worker and the employer pay a penalty for this condition, just as each would profit from its correction.

Engineering Salesmanship.—A discussion on what remuneration an engineer shall receive for his services, and what means shall be adopted to assure him of getting an amount commensurate with the services he renders, invariably leads into difficulties owing to the number of factors involved, stated Mr. Ferdinand Oudin in a paper presented before the Chicago Chapter of the American Association of Engineers. That this question of remuneration is fundamentally one of salesmanship is evident when we give some consideration to what constitutes a sale and what is a salesman. There is one common characteristic of all business activities, namely, selling. The agriculturist produces crops to sell the manufacturer makes a product to sell; the wholesaler and retailer buy to sell. Indeed, if we broaden our vision so as to take in all of the people, we find the same characteristic of sale. The producer and distributor supply necessities and luxuries to each other and to the rest of the world, and the people of other vocations sell their services in the business world to one another. Business men and others buy the knowledge, skill and talent of the lawyer, preacher, doctor, teacher, mechanic, or engineer. But we also find that it is not only true that everybody has something to sell, but that patrons must be made. This indicates to us that salesmanship is the power to persuade people to purchase that which we have to sell at a profit. The engineer must be able to persuade the patron, his employer, that his services are the kind the patron needs, and that he not only needs them but wants them. So we see that salesmanship is a necessary factor in disposing of the engineers' services; whether this salesmanship shall be individual or collective cannot be decided lightly; probably a combination of both will give best results.

Maintaining Water Supply in Yard Mains While Repairs Are Being Made

In making changes or repairs on the fire main systems of large industrial plants, the amount of protection removed while the water remains shut off is frequently excessive and creates a considerable hazard. This condition can often be improved by installing sufficient sectional control valves, but even then, in large plants, outlying portions of the fire mains are frequently rendered useless when section control valves are shut to allow of repairs, etc.

A system that has recently been adopted by a corporation owning several large plants is described by Mr. George H. Greenfield in a bulletin of the National Fire Protective Association, as follows:

Double female hose couplings have been provided at the different works, and, before any section is shut off, the fire main plan is carefully examined by the fire chief. In a great many cases it is found possible to bridge a section of water main that is out of service, or to join up an outlying section by running lines of hose from hydrant to hydrant, using the double female couplings.

In summer the water is turned on, but in cold weather the lines of hose are run and all made ready, but water is not turned on.

During a recent shut-off one Sunday to allow of some extensions on the fire loop at one of the works, the adoption of the above system made it possible for water to be maintained on the lumber yard section, which included five hydrants and three large sprinklered lumber storage buildings. Under normal conditions the protection would have been entirely removed whilst the changes were being made.

A few 6, 8 and 10-inch soft taper wooden plugs, about 2 ft. long, are kept in the fire station, so that when mains are being cut they can be plugged in a hurry should occasion arise.

The double female hose couplings also serve the additional purpose of allowing municipal fire departments steamers to couple up to the yard hydrants and boost the pressure, should this be necessary through failure of the plant fire pumps, or through excessive demand for water.

Combination Manhole and Sand Trap for Tile Drainage

A useful combination manhole and sand trap for tile drainage systems is described in a recent issue of The Highway Magazine. The device is made of corrugated iron, heavily galvanized. The advantages claimed for it are as follows:

First, the combination manhole and sand trap serves as a settling basin for any sand or silt which may pass through the drain pipes.

Second, the trap extends a foot below the drain, there being a chamber which collects and holds the sediment until such time as it can be conveniently removed.

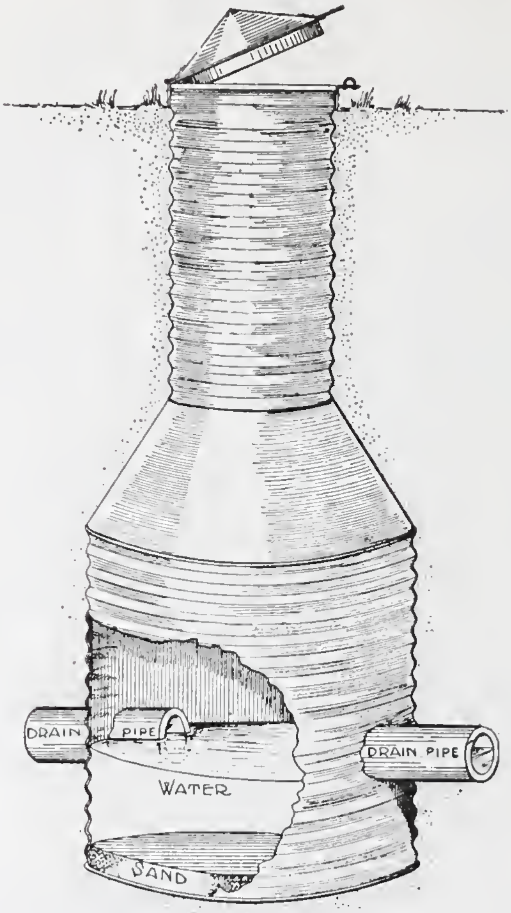
Third, the manhole may be provided to take care of surface water, where it is desired, thus serving a double drainage purpose.

Fourth, provision can always be made for flushing the drain, which is, in itself, a decidedly important feature.

Fifth, the sizeable opening above provides a means for the operation of a root-cutting or drain-cleaning device, operated by sewer rods.

These manholes may be used as observation wells. Each manhole is provided with a conical cover, hinged on one side and supplied with a hasp on the other for locking.

The height of the device over all is 10 ft. It is 2 ft. wide at the neck and 4 ft. at the bottom, and can be furnished with or without a metal bottom as desired.



Combination Manhole and Sand Trap in Place.

Education for Metermen.—In a discussion of a committee report at the recent convention of the National Electric Light Association several delegates described metermen's courses which their companies had based on their experience during the war. The opinion was that better results are obtained by training the men under an instructor and conducting reading courses and questions and answers than by allowing men to study under several men's guidance as is generally done. Such courses help considerably to weed out the misfits. Some delegates spoke highly of the employment of women in meter laboratories, while others were not so commendatory. It was brought out that small companies are in need of a meter-testing service because they cannot perform it very economically.

Personals

W. I. Baucus has been appointed city engineer of North Adams, Mass.

V. A. Harding has resigned as superintendent of the municipal water and light plant of Goshen, Ind.

Capt. H. R. F. Helland of San Antonio, Texas., has been elected city engineer of Waxahachie, Texas.

T. H. Johnson has resigned as city engineer of Sioux City, Ia., and will engage in a consulting practice, specializing in concrete paving work.

A. D. Smith has resigned as city manager of St. Johns, Mich., and Theo. H. Townsend, county school commissioner, has been selected to succeed him.

Earl R. McKesson, associate professor of civil engineering at the Virginia Polytechnic Institute, has resigned and will engage in construction work near Petersburg, Va.

T. R. Neiswander, who has been in the engineering department of the Water Users' Association, Phoenix, Ariz., for some time past, has accepted the position of engineer in charge of the irrigation system of the Edwin R. Post farms in the Santa Cruz Valley.

Robert Coltman, Jr., recently with Barclay Parsons & Klapp, 60 Wall St., New York, on the construction of the twin graving docks at Norfolk, Va., for the Emergency Fleet Corporation, has resigned to become construction engineer for the American Mongolian Trading Co. at Kalgan, China.

A. E. Chandler has been appointed executive head of the Water Commission of California. Under the new law there will be only one paid member of the State Water Commission drawing a salary of $5,000 yearly. There are two other per diem members—W. A. Johnstone of San Dimas and A. W. Mason of Bakersfield.

George S. Brockway, sergeant Co. B, 17th U. S. Engrs., A. E. F., recently returned from overseas, having been stationed throughout the war on heavy construction work at St. Nazaire, France, is returning with Mrs. Brockway to Fellsmere, Fla., where he will rejoin the corps of engineers under Mr. Irwin S. Lloyd, Chief Engineer of the Fellsmere Farms Co.

Railways and Excavation Monthly Issue

ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging (c) Quarries and Pits
(b) Rivers and Canals (d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings (c) Harbor Structures
(b) Bridges (d) Miscellaneous Structures
(e) Properties of Materials

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Why Not Carry Freight Free, Mr. Wooley?

Robert M. Wooley, member of the Interstate Commerce Commission, is opposed to raising freight rates, not because the net earnings are likely to be adequate, but because the deficit can be made good by general taxation. In a recent address he said:

"Isn't it far sounder economics to take care of railway deficits through the national treasury, whose coffers are replenished through taxes levied where they can best be borne, than to force an increase in rates?

"Bearing in mind that the three principal elements in the cost of the finished product are the price of the raw material, the price of labor and the price of transportation, aren't we, by retaining control of the roads and refraining from increasing freight rates, pegging down one corner of the vicious triangle?"

This "vicious triangle" is vicous only in the imagination, but the plan suggested by Mr. Wooley is "vicious" in reality. He would have taxpayers meet part of the cost of handling freight for other people, on the theory that every taxpayer is a wealthy person who can afford to be bled. Even in these days of "raw deals" for taxpayers, we have not heard of a bolder plan to perpetuate unjust taxation.

Why not go a step farther and carry all freight free? If Mr. Wooley's theory is correct, by abolishing freight charges one corner of the "vicious triangle" of living expenses would vanish. Indeed, it would more than vanish, for he estimates that every dollar added to freight charges is swelled to four dollars by the time the charge is assessed against the ultimate consumer. If so, it would follow that every dollar of reduction in freight charges would save the ultimate consumer four dollars. Hence if the present total freight charges of 2½ billions annually were eliminated entirely by the simple plan of carrying all freight free, the ultimate consumers would save four times 2½ billions or 10 billion dollars, which is more than one-third the total annual wages and salaries paid in America!

We have previously heard this hocus-pocus theory that freight charges are multiplied several fold by manufacturers and middlemen in making their prices, but we had never supposed that an Interstate Commerce Commissioner would believe such nonsense.

The belief that manufacturers and merchants multiply freight charges in fixing their prices is prevalent among those who know little or nothing of industrial economics. The error springs from confusion as to the fundamental significance of the practice of adding to costs a percentage for profit. A wholesale middleman,

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 380 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

for example, adds 10 per cent to the purchase price of goods to obtain his selling price. Since the purchase price includes the freight charge, he apparently adds 10 per cent to the freight charge. But the fact is that were the freight free he would increase his percentage, since the percentage method of calculation is merely a convenient way of estimating what his selling price must be in order to cover his expenses and provide an adequate income for his own services. Since his expenses remain unchanged by any change in freight charges, and since the same holds true as to his remuneration for his own service, it is obvious that if freight charges constituted half the total cost of the goods, he would double his percentage (making it 20 per cent instead of 10) were there no freight charges.

Director General Hines appears to be laboring under the same fallacy as Mr. Wooley. We suggest to both of them a few hours' talk with manufacturers and merchants on their methods of pricing goods, and the true significance of the percentage method of estimating "profits."

Suggested Economic Congress of Workers and Capitalists of All Classes

Warren S. Stone, grand chief of the Brotherhood of Locomotive Engineers, in his recent talk to the Interstate Commerce Committee of the House of Representatives said:

"For whatever the worker receives in wages he must spend in the necessaries of life. The cost of his living is determined by the sum he earns plus the profit he is charged on his own labor. And, as a group, labor is forever prevented from bettering its lot because of the profits exacted by the employer. So long as consumers are forced to pay extortionate profits on their own earnings to a third interest there is no solution of the industrial problem."

Note particularly the full significance of Mr. Stone's statement that "labor is forever prevented from bettering its lot because of the profits exacted by the employer." This is the belief not only of most labor unionists but of many socialists. If it were a true statement, then labor could not have bettered its lot ever since the system of capitalism came into existence, for profits and capitalism have gone hand-in-hand. But labor has "bettered its lot" far more during the past century than during all centuries before, and the last century has witnessed the greatest progress of the capitalistic system. Evidently, then, Mr. Stone would be forced to modify his generalization were he placed under cross-examination. He would, however, undoubtedly stick to his belief that all profits are extracted from the earnings of workmen, which is tantamount to asserting that human productivity is attributable entirely to workmen.

Labor union leaders have preached this doctrine for generations. It is a doctrine that can not be supported by facts, and one that could never have secured standing room in the brain of any thinking man were it not for the psychological effect of prejudice. Prejudice makes men see only what they want to see. The laboring man, for example, is prejudiced in favor of his own class. He sees that without the labor of his class, all other classes would be powerless; and from this he falsely infers that labor is the only important factor in production. By a parity of reasoning the heart might conclude that the other organs should have no share of the blood that passes through it, since it admits the other organs would die were the heart to cease beating.

Warren S. Stone and thousands of other labor leaders are prejudiced by their class consciousness to a degree that they do not realize. But while their prejudice leads them to avoid reading books and articles that would modify their views, we believe they are not so stubborn as to refuse to listen to facts were the facts presented by sincere men who advocate the capitalistic system.

Inventors, engineers, managers, business men, bankers and all the vast host of mental workers should, somehow or other, present their experience and conclusions to the greater host of manual workers.

Perhaps there should be an economic congress of all classes of men in America, each class represented by several delegates. At the sessions of this economic congress every class would have a chance to be heard, and a chance to question the representatives of other classes. For the first time in history, every class of worker, manual and mental, would be able to listen to every other class, to hear his facts and his inferences from them, to listen to his aspirations and his proposals for attaining them.

It may be said that our two houses of Congress already give ample opportunity for such a conclave of classes. Unfortunately, however, our legislative representatives are mainly professional talkers, as is evident from the fact that most of them are lawyers. Talk from professional talkers we have had in abundance, but talk from the doers has been largely confined to their own circles. What is needed is talk from every class of doer to every other class. Let Mr. Stone, the unionist, for example, tell why he believes that profits and wages are inimical. Then let him hear Mr. Vanderlip, the banker, tell why and how the capitalistic system in America has made it possible for manual workers in this country to earn several fold as great wages as in Europe. Let Mr. Edison, inventor and capitalist combined, tell what inventors backed by capitalists have already accomplished, and give his forecast of what will be accomplished in the next fifty years under the capitalistic system.

The "New Republic" recently said that socialism and unionism have organizations that are vigorously attacking capitalism whereas capitalism has no organization and therefore attempts no defense. Capitalism has been pictured by socialists as an organization of profit makers that brought about the world war to increase the profits. But where is the organization? Who is its head? Where does it hold its meetings. The truth is that capitalism is a term applied to the system of private ownership of wealth used in the production of more wealth. From private ownership of wealth there evolved the practice of paying rental for its use, the rental being called interest when applied to capital other than real estate. This economic system, now centuries old, is being vigorously attacked. There is no organization to support the system of capitalism, but there is one vigorous organization that aims at its destruction. The socialists avowedly oppose capitalism, although the labor unionists have not hitherto joined in this opposition, it is plain that they are in sympathy with the socialistic opposition. It is true that the unions of railway men disclaim any intention to "democratize" all industry, but they admit that they believe in "democratizing" railways, public utilities and mines. What is even more significant of their purpose is their severe criticism of the system of profits, as above exemplified in Mr. Stone's statement. In their recent manifesto to the public the railroad unions said: "We ask that a lease be granted to a corporation (to be managed by the public and the railway employes) created not for profit, but for public service." Evidently the word profit seems to these labor unionists to be synonymous with extortion. That profit will continue thus to be anathema to them is evident, unless they become better educated in economics. Left to themselves their strong class consciousness and prejudices are likely to prevent their studying economics with broad sweep of vision. Probably their attitude toward the capitalistic system would be changed to a marked degree were they to discuss the subject from every aspect in an economic congress such as we have suggested.

Mr. Wilson's Remedies for High Prices Show His Lack of Scientific Training

President Wilson, in his address to Congress on the subject of high prices, did not mention inflation of the currency; yet professors of political economy are practically unanimous in attributing higher prices to increased stocks of money, the world over. President Wilson lacks a scientific training, and never was that lack more obvious than in this particular address. An engineer called upon to discuss the reasons for "the high cost of living" would first have enumerated the economic forces or conditions at work to produce high prices. Next he would have compared these forces in different countries where high prices prevail. This would lead to the conclusion that there are only a few similar conditions that are to be found in every country afflicted with greatly increased prices. Finally, by comparing these common conditions, it would be seen that inflation of currency must be regarded as one of the most conspicuous of the conditions attending the rise of prices.

The next logical step would be to determine whether in those countries where currency inflation is greatest the prices are highest. Russia would be found to lead every country in currency inflation, also in high prices. France leads Great Britain, and Great Britain leads America, both in currency inflation and high prices. Perceiving such facts, an engineer would plot the quantity of currency, the bank deposits and the average prices (price indexes) by years, for each country. If these curves were found to be substantially parallel, he would conclude that there is a direct relation between the quantity of money and average prices. In passing, we may say that Prof. Irving Fisher has plotted such curves for the last few years and has shown them to be nearly parallel.

Having thus seen that changes in the volume of currency are accompanied by corresponding changes in price levels, certainly no report would be made by an engineer to a legislative body on the question of high prices without mention of currency inflation. Yet Mr. Wilson's address does not contain a single allusion to currency inflation. On the other hand, it abounds in charges of "profiteering," for which the main remedies proposed involve legal action against speculators, hoarders of produce and suppressors of competition.

Illustrative of Mr. Wilson's defective training in logic, and particularly in logic as applied to economics, we note his reasoning that the increases in the stored supplies of certain foodstuffs during the past year accounts primarily for increments in the prices of those foods. He does not show that a year ago American stores of all foods were at an abnormally low ebb, because America was straining every resource to feed her allies. Nor does he show that certain abnormally large stores are coincident with very low prices. The stock of copper, for example, is abnormally great, yet the price of copper is only about half as high as it was just before the war ended. The accumulation of large stocks of goods acts rather to lower prices than to raise them, unless there is prospect that the demand will be sufficiently great to absorb the entire stock. In the case of certain foods the prices have contrived to rise, even in the face of increasing stocks on hand, because food-depleted Europe is buying from America on a large scale, as our enormous balance of trade bears witness. The same holds of textiles, shoes and other products. Mr. Wilson proposes forcing the holders of stocks of goods and supplies to throw them upon the market, in order to force prices down. A slump in certain prices can undoubtedly be effected in this way, but at the cost of a subsequent rise in the price level that will carry prices above what they now are. Almost any standard treatise on political economy makes clear the destination between "hoarding" to corner a market and "storing" to meet prospective demands; but Mr. Wilson recognizes no such distinction.

In another respect the President discloses ignorance of economic matters that is quite as surprising. He advocates marking goods with the price paid for them to the wholesaler by the retailer, as a way of disclosing the retailer's profit. Every merchant, and almost every well informed professional man—certainly every civil engineer—knows that profit can not be calculated by deducting the wholesale purchase price from the retail selling price. To the wholesale price must be added all other items of cost, including freight, drayage, rent, interest on the investment, depreciation, taxes, insurance, light and heat, losses from bad debts, salaries of clerks, accountants, deliverymen, etc., and a fair salary for the retail merchant himself. When all elements of cost are added to the wholesale purchase price, and the total cost is deducted from the selling price, there is usually not much profit left for the average merchant. This is shown by the very large percentage of failures recorded every year in the retail merchandising field. It is also shown by the fact that relatively few retail merchants ever build up a large business, thereby indicating great wealth.

Undoubtedly present methods of retailing goods and produce are expensive, and retail prices are consequently higher than they need be. But the high cost of retailing is not to be remedied by making public the wholesale purchase prices, as suggested by Mr. Wilson. The remedy will not consist in disclosing to the public only a fraction of the cost to the merchant. Probably no satisfactory solution of this great economic problem can be found short of restricting competition in the retail field, coupled with better economic education for those engaged in managing such business. Socialists are entirely right in urging that competition in the retail merchandising field leads to excessive costs

A few years before Woodrow Wilson entered political life he wrote an article for Scribner's Magazine, entitled, "What Is a College For?" We abstracted the article in our issue of Sept. 20, 1916, and commented upon it. Mr. Wilson held that a college course leading to the degree of Bachelor of Arts is the only course broad enough to train students to be successful "leaders of men." We took issue with that conclusion, contending, with Herbert Spencer, the English philosopher, that those who aim to be leaders of men should secure a thorough education in science and a training in scientific methods of solving the problems of every-day life as well as the special problems that confront inventors, engineers, political leaders and others. We have watched with particular interest the sort of political leadership that Mr Wilson has shown. Its defects have been precisely those that we outlined in the article above mentioned, which are well illustrated in his latest message to Congress a message that advocates measures of public relief that are, at best, mere palliatives.

Give the Plumb Plan of Railway Democratization a Trial, But on a Moderate Scale

Temporarily, at least, the capitalistic system has been overthrown in Russia. While in Great Britain the nationalization of railways and mines, which is demanded by labor unionists, may become the first step toward a general abolition of private ownership of capital. Following the example of their British cousins, the organized railway employes of America are demanding the "democratization" of the railways. The American Federation of Labor joins in the demand, candidly saying that "democratization" of the railways is only one step toward the goal of general democratization of all industrial management.

While "democratization of industry" is susceptible of several definitions, it seems evident from the demands of the railway labor unionists that the ultimate intention is to eliminate capitalists entirely, save only such as are satisfied to invest money at bond interest rates. In other words, the word profit is to become an obsolete term if the plans of the labor union leaders can be put into effect. Carried to its logical conclusion, this form of "democratization of industry" differs no more from socialism than "air-borne mist" differs from "clouds."

We are ready to join the movement to eliminate profits entirely, just as soon as experience has demonstrated that the average workman and his family will be gainers by so doing. But we insist that experience should be our guide in this matter, as in all others where economic questions are involved. Outside of Russia there is, as yet, no nation-wide experience to which appeal can be made for guidance in deciding whether the existing system of capitalism, with its concomitant profits, should be abolished. Of course, there is China, a country almost without capital and with a capitalistic system of the crudest sort. One may point to the 15-ct. daily wage of the average Chinaman as evidence that a nation may almost starve for lack of modern capitalism. But the reply will be that the Chinese owe their desperate poverty to general ignorance.

In arguments relating to political and industrial economies, little progress is usually made by citing other countries as examples, for there are so many varying factors that it is difficult to establish what is the effect of each. So we are generally compelled to experiment in our own country where we can have all conditions alike save those whose effect is to be determined. Hence we should experiment in America to determine whether profits should be eliminated entirely. It does not follow, however, that any experiment should be nation wide in its scope. An experiment should be conducted on a large enough scale to yield data that will be of use in judging whether to adopt the new plan nationally. But the experiment should be made on as small a scale as will yield the desired data, for to go beyond that will be unnecessarily expensive.

Railway labor unions are demanding a nation-wide democratization of the railways," and they threaten congressmen with loss of their positions if they refuse to comply. Congress can answer that if the proposed plan of railway democratization has real economic merit, the merit can be shown by applying the plan to a part of the railway mileage of America. For example, let it be tried out on the New York Central and the Northern Pacific Ry. systems. These two railways are among the best, and together they would form a transcontinental system well designed to meet competition.

If, under "the Plumb plan," these two railways could not show better economic results than other railways, would it not be evident that Glenn E. Plumb is probably a better lawyer than industrial economist?

Mr. Plumb, in advocating his plan before a congressional committee, suggested that if it were not adopted by congress there might be a revolution to secure the adoption of "some such plan." Revolutions are not needed in America to secure a test of any economic scheme. Voters can always bring about a test. The real danger lies in their making the test on a larger scale than is needed to prove the worth or worthlessness of a new plan. Untrained in scientific methods of solving economic problems, Mr. Plumb has induced the equally untrained members of the majority of the American Federation of Labor not only to endorse a plan that is radical in the extreme, but to demand that the plan be at once put into effect throughout the greatest single industry in America outside of farming.

By all means let the plan of democratizing industry be tried. Let it not be confined to railways. But above all let the trials be conducted on a moderate scale. The science of deductive reasoning is still a long way from such perfection that results can be predicted with accuracy in any realm where a great many forces are operating coincidently. Of all the realms where complexity reigns, the kingdom of the human mind is the most intricate. In that realm it surely behooves us to hold fast that which is good and to move cautiously in securing that which seems better.

"We Now Demand Industrial Freedom"

For many years socialists have used such expressions as "wage slavery" and "capitalistic autocracy" to indicate their opinion of the existing industrial system. Recently labor unions in Great Britain have adopted similar terms, and now those terms have become part of the propagandistic vocabulary of labor unions in America. For example, Warren S. Stone, head of the Brotherhood of Locomotive Engineers, recently said to a committee of congressmen:

"We exist under government, but by industry we live. Under such a system, the majority of a democracy can through their government enjoy only such rights and privileges as an autocracy in industry permits them to receive.

"We now demand industrial freedom. This can only be achieved by permitting producers and consumers to share in control of the management of their means of existence. The machinery for attaining this result we believe is embodied in the plan outlined in the Sims bill."

The Sims bill embodies the Plumb plan of railway organization, which the officials of the railway unions describe as follows:

> "In labor's bill providing that the public take over the railroads and establish a tripartite control between the public, the railway operating management and the employes, the labor organizations of America have established this new policy which envisages their condition not only as producers, but also as consumers.
>
> "It marks the step by which organized labor passes from demands for wage increases to demands that the system of profits in industry be overhauled. Hitherto, during successive wage negotiations and arbitration awards, we have called for provisional settlements only, of questions arising out of differences as to wages, hours and conditions of labor. That 'principle of genuine co-operation and partnership, based upon a real community of interest and participation in control,' of which President Wilson has spoken to Congress has been ignored both by labor and by the private owners of the railroads.
>
> "What wage increases have been received during the past few years resulted only in immediately being followed by more than proportionate increases in the cost of living. Each rise in wages has turned out to mean only temporary relief for the affected workers.
>
> "As the major part of the consuming public, labor is entitled to representation on the directorate of the public railroads. As a producer of capital it is entitled to representation on the directorate of the railroads. To capital, which is the fruit of yesterday's labor, we now propose to discharge every just obligation. We demand that the owners of capital, who represent only financial interest as distinguished from operating brains and energy, be retired from management, receiving Government bonds with a fixed interest return for every honest dollar that they have invested in the railway industry. We ask that the railroads of the United States be vested in the public; that those actually engaged in conducting that industry, not from Wall Street, but from the railroad offices and yards and out on the railroad lines, shall take charge of this service for the public.
>
> "These represent all the brains, skill and energy that is in the business. They are entitled to that measure of control which is equal to their ability and their responsibility for operating the transportation properties. Then, and then only, will the service be primarily for the public, not primarily for profits to speculators and inflators of capital. As a means for accomplishing this end, we ask that a lease be granted to a corporation created not for profit, but for public service. We ask that this corporation be controlled in its management by an equal representation of the three fundamental interests upon which industry is based. The public, operating managers and wage-earners will then guarantee both the integrity of the investment required for the conduct of the industry and that return which induces it, by investing to enter the public service.
>
> "The public as consumers and the operating managers and wage-earners as producers having joined in that guarantee, will then share equally all earnings in excess of the amounts required to meet the guarantee.
>
> "This is provided by granting to the wage-earners and management one-half of the savings which they through their perfected organizations can make and by securing to the public the other half to be enjoyed by the consumers, either by charges or by reducing the cost of the service which the machinery then in existence can render. Thus the cost of transportation is automatically reduced exactly in proportion as benefits accrue to the producers of transportation. Increase in earning power of producers under this system cannot be reflected in increased costs, it must be balanced by decreased costs.
>
> "The railroads are the key industry of the nation. They affect at once the price of every necessity. As increased transportation costs are reflected in the increased price of all commodities, so a reduction in those costs must be reflected by reduced prices.
>
> "We say this because of labor's interest as consumer, as part of an overburdened public. This fundamental statement of principle we respectfully submit to the American people."

Although the present capitalistic system of profits is denounced, note that the railway unions propose to secure half the future increments in profits for themselves. They adroitly avoid calling future increments in net earnings by the name "profit," but refer to them as "savings" to be obtained through more economic railway operation. Half of all such "savings" are to go to the public and half to the railway employes. In short there are to be profits under this new plan, but they are not to be called profits! Thus in the very manifesto in which they advocate a new railway "corporation created not for profit but for public service," they propose to create profits and to divert half of them to themselves. We do not say that this may not be an improvement over the present capitalistic system of distributing savings that accrue because of better management. There are some reasons why it does appear to be a step in the right direction. But we do say that labor unionists must learn to be consistent in their use of economic terms, and avoid camouflaging old practices under new names.

Many people who "pay the freight" will recall that it was these same unions that secured "full crew laws" in several states a few years ago, thus considerably and unnecessarily increasing the cost of transportation. And the question will naturally arise as to whether the unions, once in command of the railways, will not double or triple the size of all train crews under the guise of securing greater safety of operation. Also it will be questioned whether the unions will not secure progressively higher rates of freight and passenger transportation, in order to enjoy their half of the increased profits which they call "savings."

Starting with a demand for industrial freedom and the abolition of capitalistic autocracy, would not the "Plumb plan" lead to a labor union beaurocracy such as now afflicts Australia?

These are only a few of the questions raised by the recent publication of "Labor's Magna Charta." The "Sims bill" might come eventually to be known as the simpleton's bill, were it to be rushed through congress and put into effect. Certainly it requires more evidence in its favor than the application to it of such honored titles as "Magna Charta" and "Industrial Freedom."

Book Reviews

Excavation, by Prof. Allen B. McDaniel, published by McGraw-Hill Book Co., New York; cloth, 6x9 ins., 542 pages, $5.

This new book is based largely on the author's "Excavating Machinery," published in 1913. The book is divided into two major divisions. The first division contains 16 chapters and 250 pages on excavating tools and machinery, with description of their use and some illustrative cost data. The second division contains 7 chapters and 275 pages on excavation, as for different types of "structures" such as highways, railways, irrigation, drainage, rivers, harbors, canals, trenches, quarries and pits, and tunnels.

Although the book includes both earth and rock excavation, only a small part relates to rock.

At the end of each chapter there is a bibliography of books and articles on the subject. This is an excellent feature, and it would be well were more references given.

The book is particularly well adapted for use as a text book by engineering students, and, in general, for anyone who is a "beginner." It is not so well adapted for the use of men who have had much experience, although it is not devoid of use to them. Of course it is impracticable to go very deeply into the details of so large a subject in so limited a space as 525 pages, 36 of which are devoted to the bibliography.

Industrial Goodwill, by Prof. John R. Commons, published by McGraw-Hill Book Co., New York; cloth, 5½x8 in., 213 pages; $2

Although this book is not an engineering work, it may be read with profit by every engineer and contractor who is interested in the great social problem of securing the goodwill of workers.

The author regards the science of management as being defective because of its treatment of workers as if they were mere machines. He reviews the history of the struggle between labor and capital, and concludes that, since the struggle will never end, the Government must force all employers to follow the leadership of the most progressive employers who have succeeded in securing the greatest measure of goodwill from their employes.

The chapters of the book form a series of essays on the relationship between labor and capital, the fundamental feature throughout being the emphasis placed on the economic value of industrial goodwill. The book is a valuable contribution to the subject of social economics.

Political Economy as a Science

To the Editor: Permit me to take issue with your editorial, "How Political Economy May Become a Science." My experience is that the real economic nonsense is to be found in financial journals, and not in text books written by professors. It is true that the war has caused the various financial lights to broaden slightly, but much remains yet to be done.

As an example, the "business as usual" howl which big and little business men sent out when we entered the war, and which Governor Stephens of this state made the subject of a special public statement, although a 16-year-old boy could understand the absurdity of the statement, showed the state of the economic thought of our business men.

That we need a study of economic phenomena is not doubted, but if I understand your editorial correctly you would go about this in a more direct way than do our college professors.

As an analogy let us assume that an individual was given the problem of determining the ballistic qualities of a 42 centimeter rifle ball, nothing being known of the fundamental laws of mechanics. One man would begin by studying the free fall in vacuum, and then compensate for air resistance, et cetera, while another man would eliminate the vacuum, since we are not shooting in vacuum, and spend a few million dollars in trial shooting, and at the end of the period would know no more about it than when he set out, while the other man at least had a chance of giving us a solution of the problem.

I believe if Tycho Brahe had used instruments of greater precision, Kepler would not have found the simple ellipse as the earth's orbit, but would have found a more or less irregular curve, due to perturbations; and Newton might not have seen the relationship between his law of gravitation and the movements of the planets.

These are analogies with the limitations that problems in economics are far more difficult to deal with than problems in mechanics.

It may be well to remember that the status of all machinery 200 years ago and at the end of the Greek period was practically identical. The only difference was that 200 years ago we had begun to apply theory to our machines, while the Greeks were limited to empirical solutions. Therefore the Greeks had reached the end of their development when we were at the beginning.

You say, "Quantitative facts are dug out of experience" and this is true. But without fundamental theories with which we may correlate these facts, they are worthless and worse. What we need is a profound and more widespread study of abstract fundamental principles (such as the free fall in vacuum is in mechanics), and not grandstand trial shootings which would avail us nothing.

I agree with you that engineers might be especially qualified to tackle this subject, if they will tackle it from the right end.

B. F. JAKOBSEN,
Designing Engineer,
San Joaquin Light & Power Corporation
Fresno, Cal.

Suggests Combination of National Engineering Societies

To the Editor: Those members of the engineering profession who have had an opportunity to read the report of the Committee on Development of the American Society of Civil Engineers, and who are at the same time more or less familiar with the aims and objects of the American Association of Engineers, cannot fail to discern a very evident similarity between the two.

A. S. C. E. has a membership of some 9,000, and is still growing; A. A. E. has a membership of some 7,000 and is growing very rapidly. It is very evident that, when A. S. C. E. shall have embarked upon some of the new work which has been so comprehensively outlined by the committee, there will be two engineering societies in the country of approximately the same numerical strength, engaged in exactly similar work, and entirely independent of one another, except in so far as some engineers will be members of both organizations.

It is only justice to the younger organization to concede that it was not inaugurated for the purpose of either competing with the older organization, nor of usurping its place in engineering affairs, but was rather formed for the purpose of supplementing the work of the older technical societies. Quoting from one of the pamphlets of propaganda which A. A. E. has had in print for some time.

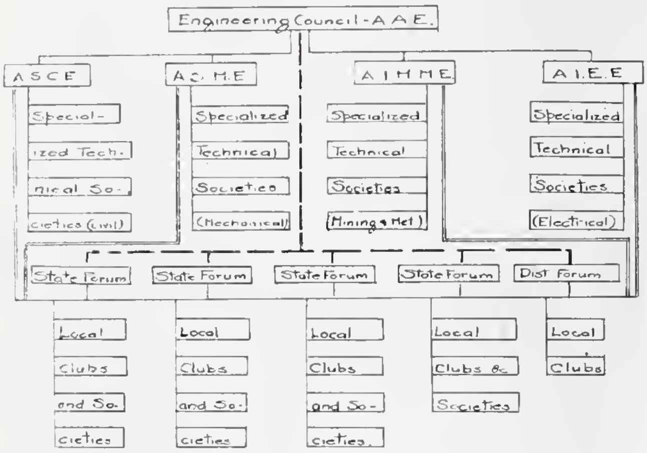
"All the other national societies have been organized to advance technical knowledge or at least have particularly devoted themselves to that object. . . . Although these societies are awakening to the fact that there is great need for something beyond their scope they have not yet developed a plan to meet the situation. . . .

"A. A. E.'s activities supplement those of the other societies. It seeks closer co-operation with them and to aid in a constructive social program."

Now that A. S. C. E. is proposing to assume a great deal of the work in which A. A. E. is now actively engaged there is bound to be, not only duplication of effort but friction and rivalry. Is this condition desirable? As a profession should engineers allow it to arise?

There will be few who will desire such a condition to exist. What then is the remedy? A combination of the two organizations in which the one will assume certain functions and the other totally different functions, yet each striving toward a common goal. In the writer's opinion this can best be obtained through some such organization as is proposed in the report of the committee above named, viz., an engineering council (national in scope), a state forum in each state or group of states, and local clubs or societies in cities and district. Intermediate to the council and the local clubs the national technical societies would stand, not functioning through the state forums, however. As branches of the national technical societies the specialized technical societies would stand without connection, directly, with the forums of the local clubs.

Diagrammed this organization would appear as follows:


Engineering Council - A.A.E.
A.S.C.E.
A.S.M.E
A.I.M.E.
A.I.E.E.
Special-ized Tech-nical So-cieties (Civil)
Specialized Technical Societies (Mechanical)
Specialized Technical Societies (Mining & Met)
Specialized Technical Societies (Electrical)
State Forum
State Forum
State Forum
State Forum
Dist Forum
Local Clubs and So-cieties
Local Clubs and So-cieties
Local Clubs and So-cieties
Local Clubs & Societies
Local Clubs

What body is more in a position to perform the functions of an engineering "council" than A. A. E? The modifications, then, that the writer would suggest to the organization as outlined by the Committee on Development would be as follows:

1. That A. A. E. be substituted for Engineering Council.

2. That a member of A. A. E. as now organized become through his present connection with A. A. E. a member of a local club.

3. That members of a local club be not, necessarily, members of a national technical society, but such affiliation be encouraged.

4. That all members of a national technical society be required to be members of a local club, and therefore have a representation in A. A. E.

5. That the state forums be representative bodies from the local and district clubs, and be responsible to A. A. E.

6. That A. A. E. be a representative body from state forums and national technical societies, and that both be responsible to it.

Some difficulties would undoubtedly be encountered in putting such a plan in operation, but they do not occur to the writer as unsurmountable, whereas the tangle which is bound to result if present tendencies go unchecked will be such that it will be impossible to straighten them out without a great deal of unnecessary strife.

C. W. HAASIS.

Cleveland, O.

Thawing Dynamite

To the Editor: Kindly refer to the "Safety Rules for Quarrying," page 658, issue June 18, 1919. Rule 28-A reads as follows:

"One of the safest and cheapest ways to thaw dynamite is to bury it in a pile of manure."

This is incorrect. Dynamite should never be buried direct in manure as this causes it to deteriorate promptly. It is proper to bury in manure wooden cases or boxes containing dynamite, provided they are tightly closed, but this qualification should always be made when recommending thawing dynamite in manure. Otherwise trouble will result.

ATLAS POWDER CO.,

Wilmington, Del.

Federal Valuation Bureau to Release One Hundred Engineers.—About Oct. 1 the Bureau of Valuation of the Interstate Commerce Commission will release from Government service in the Western district 100 engineers, whose salaries range from $720 to $3,000 per annum plus all expenses. The ages of these men range from 22 to 40 years. Many of them have had very extensive experience in construction and in maintaining railways and in general engineering experience. Many of them have been in the Government service for a period of 5 years. Parties having openings for any of these engineers should write to Mr. John S. Worley, Member Engineering Board, Bureau of Valuation for Western District, Kansas City, Kan.

Steam-Jetted Concrete for Tunnel Lining

An interesting example of relining a tunnel involving some novel features was recently described in the Railway Review, from which the following abstract is taken.

The Voksburg tunnel on the Lehigh Valley R. R. was completed in 1885. It is a double track tunnel 3,902 ft long and had a 6-ring brick lining in the center and stone lining at the ends.

It passes through a hill about 900 ft. high, and the combination of leakage of water through the brick with the exhaust gases of the locomotives has disintegrated the brick work over the tracks in many places. In other places between the tracks there are deep and extensive holes.

A year or so ago hand repairing with concrete was attempted, but this being found expensive and unsatisfactory, Mr. George T. Hand, chief engineer of the road, placed in charge of Mr. Harold P. Brown of New York the relining of the tunnel with steam-jetted concrete. For this purpose Mr. Brown designated a special car mounted on a track carried by an ordinary flat car and is controlled by two hand winches. One moves the nozzle, mounted on a trolley, which runs upon an I-beam curved on a 9-ft. radius, with the same center as that of the arch of the tunnel. The end of the I-beam projects beyond the center line of tunnel, so that the nozzle can be used to place concrete overhead between the tracks.

The second winch controls the fore and aft movement of the nozzle car for 10 ft. of working distance. A further movement causes the side of the car nearest the tunnel wall to run down hill at an angle of 45°, so that the projecting I-beam is brought back within clearance lines.

The concrete atomizer is placed on a second flat car which carries a supply of cement, sand and gravel. Steam is supplied from a locomotive fired with coke. A pressure-reducing valve set at 90 lb. reduces the steam pressure in the pipe leading to the atomizer. Connections are made by two ball joints on a 2½-in. pipe.

The work train is completed by a box car carrying the necessary tools; also a large air tank, so that compressed air can be used on the pneumatic tools for drilling weep holes and placing expansion bolts in the brickwork.

The exhaust of steam, smoke and water has covered the tunnel lining with a layer of viscous material having an acid reaction. This layer cannot be removed by scrapers, by wire brushes or by sand blasts; as the sand merely sticks to the viscous surface. Nor does a steam jet serve to clean the bricks. Mr. Brown therefore uses a spray of pebbles, hot water and steam jetted by means of the nozzle car against the surface, at 45 lb. pressure. This leaves the bricks perfectly clean and hot. A mixture of 1 part cement, 3 parts sand and 1 of fine pebbles with 10 per cent of water is at once jetted on to the cleaned surface and adheres strongly enough to check the flow of water through the brick.

No trouble is caused by the presence of the coke-fired locomotive in the tunnel. As the service in both directions is carried on one track, the work is frequently interrupted, and a locomotive hauling a heavy freight train fills the tunnel with smoke which takes some time to clear. To help in clearing away the smoke on days without a breeze a draft tube is mounted on top of the cab with a series of steam jets. This creates a powerful current of air. A dynamo on the engine supplies incandescent lights for the train, and several acetylene torches are used for general illumination.

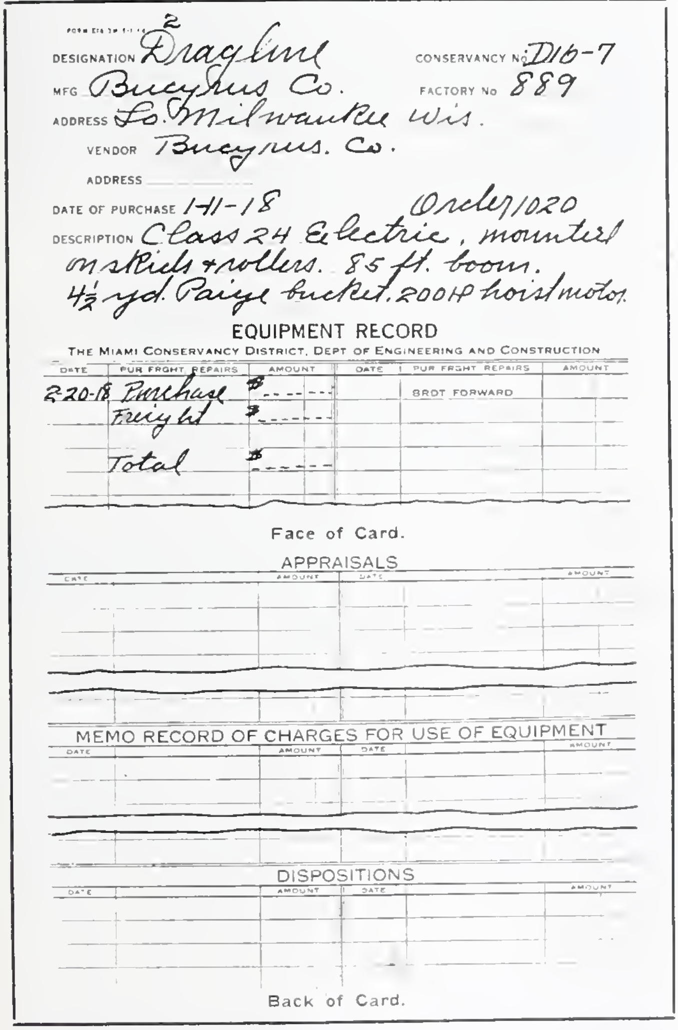
This is the first instance of the use of a coke-fired locomotive in a long unventilated tunnel. The hot concrete jetted upon the roof seems to absorb a large proportion of the carbonic acid gas generated by the combustion. The concrete sets up very quickly and no reinforcement or wire mesh is needed to hold it in place on the arch.

Fifty-two Per Cent Increase in Railway Wages in Two Years.—In testifying last June before the House Committee on Appropriations, Director General of Railroads Hines estimated that the wages being paid railway employes in 1919 were 52 per cent higher than the rates of pay in effect at the end of 1917. He stated that prices of material and supplies were 35 to 40 per cent more than they were in 1917.

How the Miami Conservancy District Keeps Records of Construction Equipment and Supplies

An efficient card index system is employed by the Miami Conservancy District for keeping records of the equipment and supplies used on the $27,000,000 flood prevention project on the Miami River, Ohio. This work, which is being carried out by force account by the district, has required an investment of $2,000,000 for equipment.

Records for each machine are kept on the form (Fig. 1). One side of the card gives the record of the equipment, while the other side shows the appraisal costs at various times, the charges for use of the equipment, and its final disposition. It is thus possible to obtain from the cards all the information essential to accurate accounting, including the amount expended for repairs and the final disposition of the machine. The card system is handled by one man.



2

DESIGNATION Dragline   CONSERVANCY No. D16-7

MFG Bucyrus Co.   FACTORY No 889

ADDRESS So. Milwaukee Wis.

VENDOR Bucyrus. Co.

ADDRESS

DATE OF PURCHASE 1-11-18   Order 1020

DESCRIPTION Class 24 Electric, mounted on skids + rollers. 85 ft. boom. 4½ yd. Paige bucket. 200HP hoist motor.

EQUIPMENT RECORD

THE MIAMI CONSERVANCY DISTRICT, DEPT OF ENGINEERING AND CONSTRUCTION

DATE	PUR FRGHT REPAIRS	AMOUNT	DATE	PUR FRGHT REPAIRS	AMOUNT
2-20-18	Purchase	$		BROT FORWARD	
	Freight	$			
	Total	$			

Face of Card.

APPRAISALS

DATE	AMOUNT	DATE	AMOUNT

MEMO RECORD OF CHARGES FOR USE OF EQUIPMENT

DATE	AMOUNT	DATE	AMOUNT

DISPOSITIONS

DATE	AMOUNT	DATE	AMOUNT

Back of Card.

Fig. 1.—Card for Machinery Record. (Actual Size of Card 5x8 in.).

Supplies and repair parts are distributed through a large central warehouse at Dayton, to local warehouses on each job. The central warehouse records are kept on the form shown as Fig. 2. This card records the quantity and value of the material or parts on hand, so that the warehouse superintendent can tell at any time the exact amount of any article he has in stock.

The local warehouse is supplied from the central warehouse on written orders from the division superintendent or division engineer. Each out-going item is priced, and the wagon bill of lading is made out in duplicate and given to the truck driver, who signs it as a receipt and delivers the supplies to the local warehouse. The local warehouse man checks the load, keeps one copy of the bill and sends the other to the central warehouse.

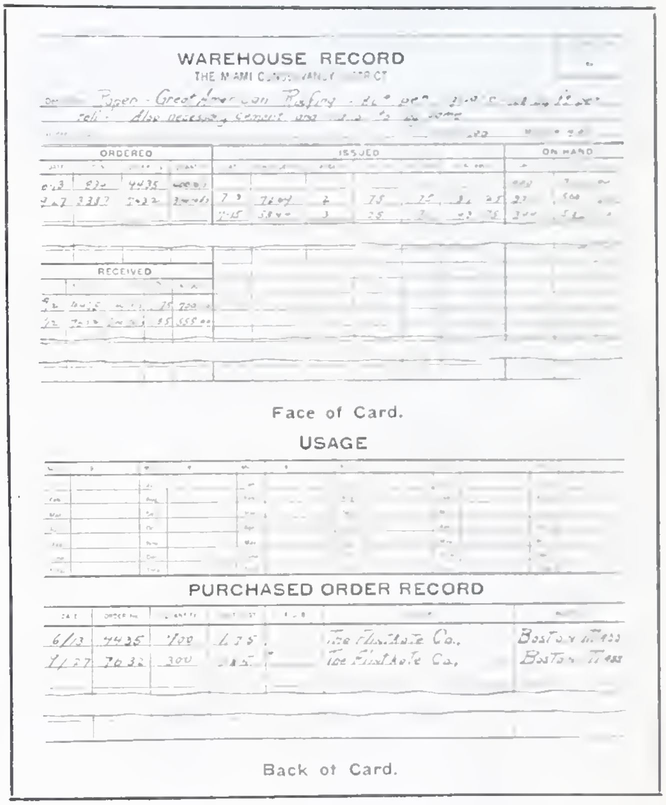
Growth and Decline of Jitney Business in Los Angeles

Jitneys commenced to operate in Los Angeles during July 1914, and their number increased with such rapidity that there were 500 in operation by the end of the year. The number of jitney permits issued the succeeding years were 1,300 in 1915, 1,000 in 1916 and 600 in 1917. The number of jitneys operating at any one time seldom exceeded 100, as the old jitney operators dropped out about as fast as new operators entered the business. During the year ending June 30, 1918, the decline in the number of jitneys operated was extremely rapid: The total number during July, 1917, was approximately 200, and in June, 1918, there were only 32 in operation. This decrease, according to the ninth annual report of the Board of Public Utilities of Los Angeles, was due to several causes, mainly as follows:

(1) Increase in cost of equipment, gasoline, oil and tires

(2) High wages offered for labor by shipyards and other war industries.

(3) Restricted legislation which prohibited the operation of jitneys within the congested business district of Los Angeles.



WAREHOUSE RECORD

THE MIAMI CONSERVANCY DISTRICT

ORDERED

ISSUED

ON HAND

RECEIVED

Face of Card.

USAGE

PURCHASED ORDER RECORD

Back of Card.

Fig. 2.—Card Used at Central Warehouse for Records of Supplies and Repair Parts. (Actual Size of Card 10½x12 in.).

The above mentioned report also gives some interesting statistics on the earnings of jitney operators, the figures being based on checks made on certain days from 6 a. m. to 12 p. m. The average receipts per car on the days the checks were made ranged from $4.81 on April 9, 1917, to $7.77 on July 11, 1917. On the latter date, for instance, 177 cars were operating. The total number of round trips was 2,213 or an average of 12 per car. The average number of miles per car was 124 and the total receipts was $1,376. The average receipts per car mile on this day were 6.2 ct. On the day the low figure of $4.81 was made, 286 jitneys were in operation, making a total of 2,366 round trips, or 8 per car. The number of miles per car was 91 and the total receipts for the day was $1,385. The average receipts per car mile were [illegible] ct.

Eight checks in jitney operations were made in 1915, 14 in 1916, 15 in 1917 and 6 in 1918. The average receipts per car and per car mile based on the figures obtained in these checks were as follows:

	Average daily receipts per car	Average [illegible]
1915	$5.68	[illegible]
1916	5.71	.51
1917	6.17	.54
1918	7.81	.52

Efficient Plant for Casting Concrete Blocks for Miami River Revetment

In connection with its flood prevention work on the Miami River the Miami Conservatory District will cover a considerable length of the new river banks with a concrete lining. The lining also will cover a 35 ft. strip of river bed adjacent to the banks. The latter portion will consist of a flexible mattress of concrete blocks woven together by steel cables. About 400,000 blocks will be required for the mattress. These blocks will be 1 ft. x 2 ft. x 5 in. in thickness, with narrow faces beveled ¼ in. from their center line each way and with holes located 6 in. from the short edges of the block. The holes are ¾ in. in diameter and take a ½ in. steel cable. The efficient plant and ingenious devices, developed for the casting of these blocks, are described in the Miami Conservancy Bulletin, from which the matter following is abstracted:

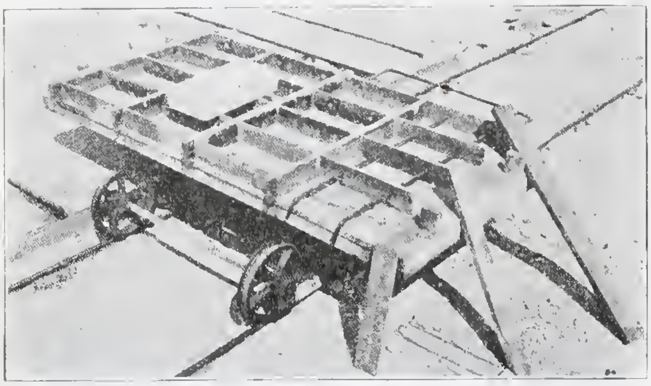


Fig. 1.—Car With 16-Celled Concrete Form.

The plan of the forms for the blocks, as developed by Mr. Harry Price, of Price Bros., contractors, who are doing the work, is shown in Fig. 1. For economy in handling, the blocks are molded on small flatcars, 16 blocks to the car, remaining on the cars from the time they are cast till they are unloaded, a finished product, in the storage yard. The 16-celled form is built up on the floor of the car, which forms one face of the block. The cells are formed by longitudinal and cross pieces, forming the partitions, 2 tenons on each end of each longitudinal piece slipping rather loosely into corresponding mortises in the cross pieces, which are longer. A partition piece of each kind is shown leaning against the end of the car. The center cross piece is bolted to the car platform; all the other pieces are loose.

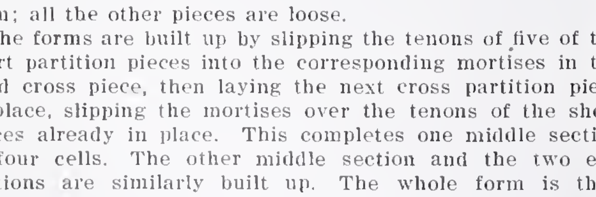

Cement & Stone Bin
Track Mixer to Gravel and Sand
Note: Arrows indicate direction of car movement
Screen
Motor Shed
Apparatus for Shaping Wire Reinforcing
Stone Crusher
Elevator
Mixer
Track from Stock to Crusher
Movable Track
STORAGE
Pipe Line for Sprinkling System
Traveling Stiff-leg Derrick
Curing Yard
8 Tracks
Transfer Track
Transfer Track
SPACE
Stock Pile

Fig. 2.—General Plan, Concrete Block Plant.

The forms are built up by slipping the tenons of five of the short partition pieces into the corresponding mortises in the fixed cross piece, then laying the next cross partition piece in place, slipping the mortises over the tenons of the short pieces already in place. This completes one middle section of four cells. The other middle section and the two end sections are similarly built up. The whole form is then tightened by cross blocks and wedges inserted between the two end cross pieces and the projecting studs seen at the ends of the car platform. The top of the form is left open to receive the concrete, the freshly poured block being struck off with a broad trowel but not finished. The partition pieces are lined with sheet steel, number 16 gage and rustproof. The holes through the blocks are formed by iron rods, slipped through holes in the form partitions, as shown in the figure. Rods and partition faces are oiled with straw paraffin oil to prevent the concrete from adhering. The rods are removed while the blocks are still a little green. The blocks cure for 24 hours on the car, after which the forms are taken apart by knocking out the wedges and removing the partition pieces and the finished blocks, one by one.

The movement of the cars in relation to the general arrangement of the plant is shown in Fig. 2. Empty cars with forms made up receive the fresh concrete from the mixer and are pushed onto a rolling platform which moves along the transfer track at the left to a point opposite one of the tracks in the curing yard, to which it is then transferred, all the pushing being done by hand. (Short sections of rail on top of the rolling platform are placed to align with the tracks in the curing yard and on the same level.)

The curing yard contains 8 tracks, each capable of holding 13 cars. At the end of a day's run this yard is filled with from 81 to 83 cars, all loaded with green blocks. The next day these cars, by way of the second transfer platform (two of these being in use), are run over the transfer track at the right to the movable track (see Fig. 2), in the storage yard, over which they pass to the point where they are unloaded to await transportation to the river levee. The blocks remain in the curing yard about 24 hours. The regular day's run is 81 cars, or 1,296 blocks, enough extra carloads being cast during the week to bring the average up to 1,300 blocks per day. After the blocks are unloaded, the forms are taken apart, cleaned, oiled, set up again, and returned to the plant for a fresh load of blocks.

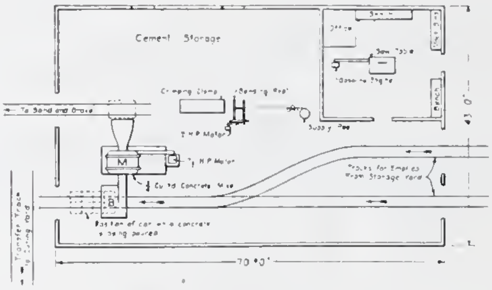


Fig. 3.—Floor Plan, Concrete Block Plant.

The finished blocks are kept wet for several days by a sprinkling device made by running down the length of the storage yard a light weight pipe with slots sawed in its upper quarter at proper intervals.

Cement for the concrete is brought by truck and unloaded by hand. The gravel is obtained from the bed of the Miami River. It was deposited in a stock pile on the bank by a dragline excavator, the plant being close to the river. The gravel is taken from stock pile by a traveling stiff-leg derrick with ½ yd. clam shell bucket (see Fig. 4), and dropped into a car running on a track on a trestle. The car dumps into the hopper of a stone crusher, from which an elevator takes the crushed material to a gravel screen which separates it into two sizes—coarse aggregate, 2 in. to ¼ in., and sand, all below ¼ in. The screened material passes by gravity to bins and thence to hopper cars which carry it along a track to the receiving hopper of the concrete mixer.

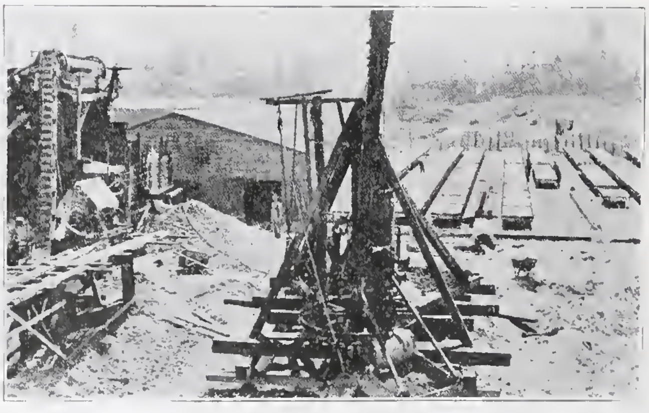


Fig. 4.—Price Bros. Concrete Block Plant.

Clamshell in foreground loads gravel from stock pile (not seen) into car shown dumping into rock crusher at left. Elevator belt to left of car takes crushed gravel to screen above, whence it passes to bins below and then by cars to mixer. Curing yard at right. Storage yard in distance. Mixer, etc., in house at left.

From the mixer (M, Fig. 3) the fresh batch pours into a mortar box B, one batch making about a car and a half of blocks. The car with the form is rolled under the mortar box. The fresh concrete runs from the box into the forms through four gates, properly spaced to fill 4 cells of the form at a time. Four such pourings fill a car.

The fresh blocks, after being run to the curing yeard, are thoroughly spaded by a special spade made by straightening the shank of the blade of a garden hoe. They are then rough-finished by striking with a broad trowel as already stated.

The reinforcement for the blocks is of No. 7 steel wire, shaped as shown in Fig. 1. The reinforcement is laid into the form as shown and slightly lifted from the bottom as the block is being poured, in order to bring it into proper position, the fresh concrete being stiff enough to hold it in place.

The reinforcement is made from the wire by a simple and ingenious arrangement sketched in plan as part of Fig. 3. The wire coming from the supply reel passes over three grooved wheels as shown to take the bend out. It passes thence to the bending reel made out of parallel gas pipes attached to a pulley rotated by an electric motor. This reel forms it into a somewhat flattened coil. The crimping clamp is then rolled forward on its rails (not shown in cut) and its jaws bring the coil to final flatness. The coil is then removed from the reel and cut into sections of the requisite number of turns to give it the final shape seen in Fig. 1.

The rock crusher is a No. 1 jaw crusher, built by the Western Wheeled Scraper Co. The mixer is a Koehring batch mixer of 21 cu. ft. capacity, run by a General Electric 7½ hp. motor. A 2 hp. motor runs the wire bender, a 3 hp. motor the gravel screen, and a 7½ hp. motor the rock crusher. All the electric motors are of the induction type, and take current from the Dayton Power & Light Co.'s alternating current line, the plant being within the city limits of Dayton.

The labor required is as follows: wire bending machine, one man; trucks bringing cement, 2 men; derrickman; crusher and screen, 2 men; sand and gravel car to mixer, 4 men; mixer, 2 men; filling forms, 2 men; transfer car, 1 man; spading and finishing blocks, 2 men; cleaning, oiling, and setting up forms, 4 men; unloading blocks, 3 men. Add to these a superintendent, an inspector, a general utility man, and a night watchman. This totals 28 men. Much of the work has been done with 24 to 26 men.

The plant is operating very successfully and economically, and is turning out an excellent product. The contract price for the first 100,000 blocks is 20 ct. per block; for additional quantities, 16 ct. per block. Counting the expense of gravel and use of rock crusher, both of which are supplied by the District, this makes the average cost between 17 and 18 cents per block. The turnout up to July 26 was 87,500 blocks, just half the number required for the Dayton river improvement. Hamilton will require 225,000. The plant will be dismantled and moved to Hamilton to make them.

Annual Congress of National Safety Council.—Some of the most important problems before American industry today, such as the anticipation of labor unrest, increasing plant efficiency and production, decreasing manufacturing costs and the whole subject of labor management, will be discussed in connection with the general subject of accident prevention at the 8th Annual Safety Congress of the National Safety Council in Cleveland, Oct. 1 to 4. The great bulk of the accident prevention talent of the country— 160 scheduled speakers and approximately 3,000 men and women who direct the safety work of the nation's greatest industries will come together for a four-day exchange of ideas and experiences. There will be four general sessions, four round tables, and 35 sectional meetings during the congress. As all the general sessions will open at 2 o'clock in the afternoon and the sectional meeting at 9:30 o'clock in the morning it will be possible for any one to attend all the general sessions and also all the sectional meetings for his particular industry. There will be three meetings each of the metals, mining and steam railway sections, one meeting each of the marine and navigation and textiles, and two meetings of each of the following sections: automotive, cement, chemical, construction, electric railway, health service, packers, paper and pulp, public safety, public utilities, rubber, woodworking, and women in industry. The first general session will be devoted entirely to a discussion of employes' representation.

The Railroad Problem

In a pamphlet of about 70 pages entitled "Comments on the Railroad Problem," by Mr. Robert S. Lovett, president of the Union Pacific System, this well-known railroad executive has made a thoroughgoing analysis of the railroad situation and has shown in a striking way the many sidedness of the problem. He has first taken up several of the plans for administering and financing the railroads which have already been proposed and shows the weakness of each of these, and then proceeds to constructive criticism by offering the essential features of the plan designated as the "sound remedy."

The problem of the strong and the weak companies he describes as being an inevitable condition rather than a problem which can be solved, or should be solved. The weak roads are weak because of serving territory with little traffic, because of competition, mistakes in policy, unsound financing or bad management. The bulk of the nation's business is done by the strong lines and this tends to make them strong.

The plan to consolidate all roads into a few systems would undoubtedly have the effect of reducing the average of the credit of all the railroads. The credit of the strongest roads has not been any too good during the last few years. Congress has no right to compel one corporation to consolidate with another. It may give one the right to acquire the property of the other by condemnation, but it must pay for it and (here is the difficulty) pay for it in cash. It is believed that the consolidation of all the railroads into a few companies would result in each one being too large for efficient and economical management.

The plan for the pooling of net earnings Mr. Lovett claims to be essentially confiscatory, for if, as a part of this plan, the most efficient roads are limited in their net earnings it will deprive many stockholders of a large part of their only income. Congress has not the power to carry out any such scheme as this, for it is a denial of due process of law and would be taking private property for public use without compensation, contrary to the Fifth Amendment of the Federal Constitution.

Many financiers and railroad men believe that a guaranty of dividends or some definite return on the money invested in railroads is necessary in order to re-establish faith in railroad securities now constituting such an important part of our financial structure. This seems impracticable, because it is not believed that the Government, as a permanent policy, would guarantee the railroad owners a fair return upon the full value of their property and leave the management in their hands, taking all of the risks and none of the profits, whereas, if the Government should take the excess above the guaranty, then it would cease to be a guarantee, and all incentive to competition and economy by the private management would be eliminated.

The plan devised by the committee of railroad executives and submitted to the Senate committee offers, in Mr. Lovett's judgment, the best solution of the problem. Its principal features are:

A. The rule of rate-making to be provided by Congress itself, which should require that the rates be sufficient to enable the carriers to provide the requisite service and facilities, protect existing investments, and provide the new capital necessary in the public interest.

B. Compulsory federal incorporation of all railroad carriers.

C. Exclusive federal regulation of railroad securities

D. Exclusive federal regulation of railroad rates.

E. Creation of a Department of Transportation with power to act quickly and deal with emergencies, and the distribution of the regulatory powers between such Department and the Interstate Commerce Commission, with the creation of such regional or other subordinate commissions and agencies as may be necessary.

F. Modifications of restrictions upon railroad consolidations, and provision for the merging of lines when in the public interest and approval by the Commission

Mr. Lovett defines a "reasonable rate" as whatever rate Congress may fix, provided it is not so low as to be confiscatory of the carrier's property, nor so high as to confiscate the shipper's property by preventing it from moving

Other comments of Mr. Lovett taken from his discussion and explanation of the plan of which he approves, are as follows:

Railroad investors and owners will not take all the risks and forego the profits of the business. Why should they? There are too many other opportunities for profitable investment all over the world, and more now and for many years to come than ever before. Who is more deserving of encouragement, liberal treatment and appreciation, he whose money provides the railroad facilities which the public convenience and interest require and conducts his business so well that he can make a profit out of it at rates which the Government itself fixes; or the man in private business (in some lines, the more private the better for it) with no public interest involved, and only his selfish interest to serve?

If a railroad company is compelled to go to half a dozen state railroad commissions for permission to make an issue of stock or bonds, and to encounter delays running into weeks and months on account of numerous bearings before different commissions, and in meeting their conflicting policies and views, before it can deliver the securities, it will be impossible to have the issue underwritten, or if underwritten at all the cost will be excessive. In the matter of service, a cabinet officer by calling in railroad executives, and through informal discussions, could bring about changes in train service, schedules, and other things desired by the public, which if taken up with the elaborate formality and procedure inevitable in cases of a commission or similar body, would not be accomplished for weeks, and possibly months.

Economy in Painting Railway Structures

Mr. W. I. French, foreman maintenance of way painters, New York, Ontario & Western Ry., writing in the Railway Maintenance Engineer, reminds us that notwithstanding the mounting costs of material and labor, it is still "good business" to maintain structures in proper condition as regards painting. He claims that it is a custom with railroads when it is necessary to make a reduction in their maintenance forces to reduce the paint force first. Where this practice exists many bridges are gradually being eaten away with rust and the buildings are decaying, thereby producing a condition which can only be corrected after a great amount of labor on the part of the painters before the structures are in proper condition to apply paint.

When a bridge begins to rust it also begins to weaken, because rust is like a cancerous growth which is continually working and destroying. Similarly when the large scales form a certain amount of strength is taken from the bridge due to the reduction in section of the metal. Something must be done to check the rust. It is then up to the painter to scrape, wire brush or sand the steel and remove as much of the rust as is possible before applying the paint.

In many cases the season is so short from the date the work is started on the bridges that one can give them only one coat of paint, which will perhaps be the only coat which they will get until they are in much the same condition as before being painted. For this reason in most cases bridges should not receive less than two coats of paint. If the bridge receives two coats the second one is a protection to the first coat, as it seals and protects the steel from atmospheric conditions that would otherwise affect the one coat of paint. The cost to clean the bridges that are allowed to get in bad condition may be three times as much and in some cases more than it would cost to paint them in season. Since labor is the major item of cost it seems very poor economy to let them get in such condition.

Buildings and other structures built of wood, instead of rusting will decay if not kept properly painted. It seems a fallacy to permit a station or building which costs a large amount of money to go to ruin when by keeping it well painted it can be preserved for years. If people would only stop and think for a minute of the amount of work it necessitates to get a building into condition to paint after the old coat has begun to peel, fewer structures would be allowed to get in such a condition.

After a building begins to peel the only practical procedure before painting is to burn off the old paint down to the wood. If this method is not used it will continue to peel, whereas if it was given one coat of paint every four years it would keep the building in good condition at a reasonable cost. It would always look well and be in a good state of preservation.

Code of Practice for General Contractors and Subcontractors

The Contractors' Protective Association of Cleveland, an organization composed of general contractors in the building trades has adopted a code of practices to govern the relations between general contractors and subcontractors. The code follows:

Allocation of Expense.—The general contractor shall assume and pay for the different items of expense which are called for in the "General Conditions" of the specifications on all work let under a general contract, except such expense items as pertain especially to the work which is sublet by him. Such items as watchmen, telephone charges (except long distance calls), fire insurance, etc., shall not be pro-rated against the sub-contractor. Long distance telephone calls, water, electric current, compressed air, elevator service, etc., shall be charged directly to the sub-contractor on the basis of the use made of these items by the sub-contractor.

Cutting and Patching.—Sub-contractors shall assume all reasonably-to-be-expected cutting and patching of their own work, but are to be paid by the general contractor for all unreasonable cutting and patching which may be required of them. Sub-contractors shall clean up and remove rubbish made by their men.

Liability Insurance.—Both general contractors and subtractors shall assume the responsibility for personal damage to either their employes or to the public as prescribed or permitted by the laws of the state of Ohio. Sub-contractors shall not be required to carry contingent liability insurance, except as may be required for their own protection, and for the protection of the general contractor, in case they themselves become insolvent. Sub-contractors shall not be required to place their insurance in any particular manner or with any particular company, however, either the owner or the general contractor has the right to refuse to permit the risk to be carried in any specific manner or by any specific company if said owner or contractor feels that he has a just reason for taking such a stand.

Bond from Sub-contractor.—Sub-contractors are to give bond to the general contractor if the general contractor so requires, but the cost of the bond is not to be prorated against the sub-contractor.

Co-operation in Letting Work.—It is the expressed desire of the general contractors to conform with the wish of the Building Trades Employers' Association of Cleveland, that work shall be sub-let, as far as it is reasonable and practicable to so do, to members of the Building Trades Employers' Association.

Rejecting Bids by Sub-contractor.—When the general contractors have requested and taken bids on sub-contract work, at the time of making up their own bids on that work, they shall not again request sub-bids after having been awarded the general contract, but shall proceed to sub-let said work upon which they have taken sub-bids, and shall do so on the basis of the bids received, unless there shall be some good reason to the contrary.

Payments.—Sub-contractors shall invoice against the general contractors once a month and the general contractors shall make monthly payments to their sub-contractors, said monthly payments being based upon the conditions of the principal contract, except that the sub-contractors are to be paid in full for their work within 60 days after the final completion and acceptance, by the owner's representative, of said sub-contract work, unless there shall be some indication of lien or a similar reason for withholding payment. If a lien or attested account has been filed, or if it is indicated that the same will be filed, the general contractor has the right to retain from the sub-contractor sufficient funds to cover such obligations.

Waiving Lien Rights.—It shall be compulsory for the general contractor to notify the sub-contractor before closing contract with him if he, the general contractor, has waived the sub-contractor's lien rights.

Responsibility for Damage.—Each sub-contractor shall be responsible to the general contractor for any and all damage done, either to the general contractor's work or to the work of any sub-contractor by the acts or lack of acts of said sub-contractor.

Criticising Preparatory Work.—It shall be the duty of each sub-contractor to take measurements of his own work, and to criticise to the general contractor any faulty work which is preparatory and has to do with the results of his own workmanship, and in this connection the sub-contractor shall refuse to proceed with his work if he considers that it is impractical to secure the desired results over the work already in place.

Quoting Owners by Sub-contractors.—It shall be the proper method for sub-contractors, doing work under a general contractor, not to quote to owners on the job or jobs where they are doing said sub-contract work, except through the general contractor. ,

Violation of Code.—If any member of the general contractor's organization be accused by any sub-contractor in writing over his own signature of a violation of this code of practice, such written notice of violation shall be immediately referred to the Secretary of the Building Trades Employers' Association, who in turn shall refer the matter to a committee to be appointed for this purpose, and this committee shall act as prescribed by the Building Trades Employers' Association.

Electric Railway Fares

In view of the fact that the traction problem is one of the most important questions now confronting the municipalities of the country the following data will be of interest to engineers and other city officials who are concerned with the building and mantenance of electric railway lines. The figures are taken from the Aera, a Journal devoted to the interests of the American Electric Railway Association and were collected by officials of that organization.

There are 273 cities in the United States having a population of 25,000 or more. In 186 of these, fares have been increased over those prevailing before the war. Of these increases, 129 were granted by public utility commissions, 46 by local authorities, 9 became effective under service-at-cost plans, 1 was put into effect by order of the United States Court, and 1 by the company.

In 24 cities, applications for increases have been refused. In 20 of these cases, the refusal came from local authorities, and in 4 cases from the commissions.

Forty-two states and the District of Columbia have cities of more than 25,000. In 36 of these states, increases have been granted. In Connecticut, Delaware, the District of Columbia, Idaho, Maine, Maryland, Massachusetts, Mississippi, Montana, New Hampshire, New Jersey, North Carolina, Oregon and Rhode Island, increases have been granted in all cities of more than 25,000. In Arkansas, Florida, Kansas, Oklahoma, South Carolina and Tennessee, no increases have been granted in such cities.

A 10-ct. fare is being charged in 12 cities; an 8-ct. fare in 10; 6 ct. plus 1 ct. for transfers in 14; a 7-ct. fare in 15, and a 6-ct. fare in 86.

Thirty-two applications are pending before Commissions, 27 before city authorities and two before courts.

Municipal ownership has been proposed in three cities—San Francisco, Detroit and Omaha. Service-at-cost plans are being considered in Philadelphia, New Orleans, Minneapolis, Denver, Louisville, Oakland, Berkeley, and Muskogee. In six cities the service is being operated by the state, while state operations will be shortly under way in 12 more.

In 31 cities, railway companies are in the hands of receivers.

Electric Power Requirements of Rock Crushing Plant. The following figures on energy consumption of a rock crushing plant are reprinted from the Electrical World. The plant is located in Massachusetts, is equipped with a 20 hp. 550 volt, 3-phase induction motor, and is operated 8 months of the year. The crusher is fed by gravity:

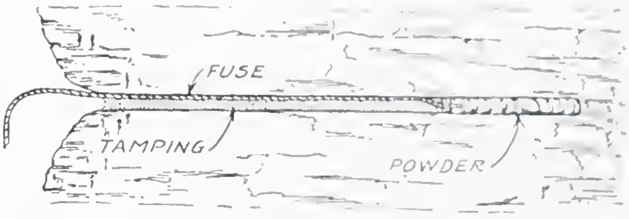
Month.	Cost of service.	Kw.-Hr.	Tons crushed.	Demand (Kw.)
May	$50.76	950	1,012	17.3
June	35.14	610	701	17.9
July	33.98	590	596	22.1
August	50.22	930	1,082	25.4
September	62.10	1,150	1,240	37.2
October	61.02	1,130	1,308	22.4
November	69.66	1,290	1,343	30.9
December	65.88	1,220	365	27.6
Total	$428.76	7,870	7,677	....
Cost per ton for energy				$0.0536
Kw.-hr. per ton				.983
Average kw.-hr. per month				.983

Advantages of Electrical Method of Setting Off Blasts

The potential energy contained in dynamite or any other explosive can be brought into activity only through the use of some intermediate firing agent. The ideal medium for this purpose should possess the following qualities

First. It must secure the full energy from the explosive in the form of useful work

Second It should be absolutely free from misfires

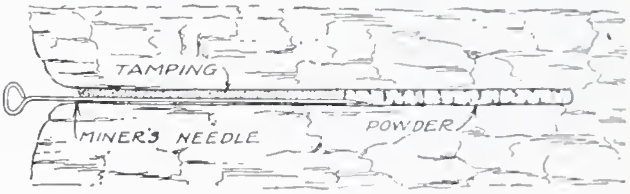


Fuse Permits Good Tamping, But Ignites the Charge in the End, and Requires an Open Flame to Light It.

Third. The blaster or user should enjoy maximum safety while using it.

Fourth. It should be able to resist adverse or poor storage conditions without deteriorating and thus becoming more or less useless.

Fifth. The cost should be low. The factor of a low first cost, however, is not a true criterion of the cheapness of any given method of detonating or igniting explosives. Though a method might be very cheap in first cost, it might not deliver the full energy of the explosive and would thus require the use of a greater amount of explosive than would otherwise be necessary. It might give rise to a large number of misfires, which are dangerous to the blaster and generally result in a total loss of explosives. It might also be unsafe or at least, comparatively unsafe, and one or more serious accidents would bring the expense far above the greater first cost of some safer method.

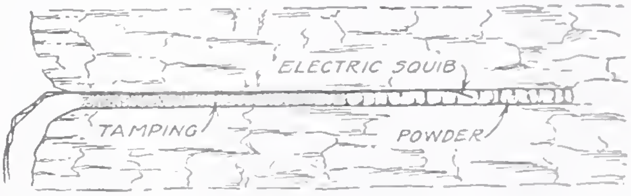


When the Needle Is Removed for the Miner's Squib a Hole Is Left Permitting the Escape of Gases.

Many methods have been devised to set off blasts An interesting discussion of the methods at present in use is given by Mr. B. Stoneking of the Technical Division, E. I. du Pont de Nemours & Co., in the August Du Pont Magazine, from which the matter in this article is taken.

Igniting Blasting Powder.—In igniting blasting powder, the principal agents are miners' squibs, safety fuse and electric squibs. If the characteristics of the ideal detonator, as given above, be taken as a standard, it will be found that miners' squibs are deficient in that they do not give the full energy of the explosive. In using miners' squibs, a passage through the tamping must be left so that the squib can "sky-rocket" back from the mouth of the hole to the explosive charge. This opening gives a vent for the gases generated by the explosive; hence some are wasted in useless whistling into the open air.

Safety fuse is much better than miners' squibs in this respect, for, when fuse is used, the hole may be tamped solid. This confines the gases. In bore holes where the charge of powder extends over several feet in length, however, safety



Electric Squibs Permit Good Tamping, Ignite the Charge in the Center and Do Away With Open Flames for Lighting.

fuse is faulty in that the ignition may occur at the point nearest the tamping. The first gases generated may start the tamping or open up a seam. Thus a considerable portion of the energy of the gas may be wasted before the explosive in the back of the hole has burned.

Electric squibs are more satisfactory than either of the other two, for the hole may be tamped solid and the squib placed in the center of the charge. This eliminates the possibility of any gases' escaping through a seam or blown-out tamping.

In frequency of misfires, miners' squibs are undoubtedly the worst offenders, for any small obstacle in the passage or blasting barrel may stop them and cause a missed hole.

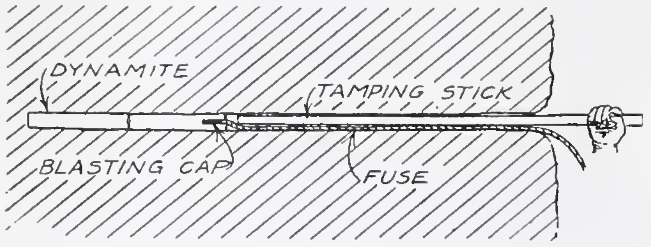
Safety fuse is better in this respect, but it, too, leaves something to be desired. Such things as a kink in the fuse due to careless tamping, cuts caused by using sharp rock particles as stemming material and the absorption of moisture from the tamping, are frequent causes of misfires.

Electric squibs are superior to the others in freedom from misfires, because the igniting material fired by the electric current is imbedded in the charge of explosives, and, if the proper current is applied through the squib, no misfire can occur.

Safety in the use of these materials is extremely important, for an accident is probably the most costly thing that can happen in explosives work. In this respect, also, miners' squibs are at the bottom of the list, for their rate of burning is uncertain, and the sky-rocket-like jump from the front of the hole to the charge of explosive obeys no rational law. The charge may explode before the blaster can get away from the blast.

Safety fuse is better than miners' squibs from a safety standpoint, because its rate of burning is comparatively uniform. Nevertheless, this rate varies somewhat even in the same grade of fuse. Moreover, the character of the stemming material and the comparative compactness of the tamping also have an effect on the burning speed. Thus it is easy to see that a blaster might miscalculate the length of fuse required to allow him to reach a place of safety. Both miners' squibs and safety fuse require an open light for their initial ignition, and this in itself is a hazard in coal mines containing gas or dust.

Electric squibs offer the greatest factor of safety for the blaster in that he can be at a point of safety before he applies the current or operates the blasting machine to fire the shot. He knows that if he has made his connections properly, the charge will explode the instant the current is applied. If it does not explode, he is perfectly safe in returning immediately to investigate the trouble. This would be a most unsafe proceeding with either safety fuse or miners' squibs. No sparks or open lights are required to set off electric squibs, so they are quite safe to use in the presence of gas.



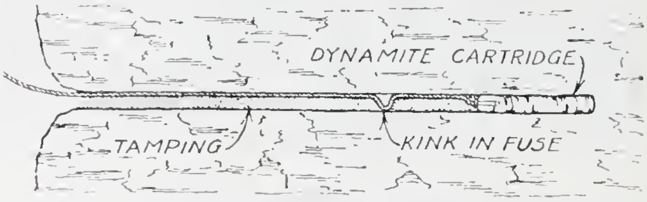
Fuse May Sometimes Be Bent and Broken by the Tamping Stick.

As far as resistance to poor storage conditions is concerned, miners' squibs very easily absorb moisture and are useless in such a condition. Safety fuse will also absorb moisture if subjected for too long a time to moist conditions. It also requires a moderately cool place, for too much warmth has a tendency to cause asphaltum or similar water-proofing material to liquefy and penetrate the powder train. Excessive cold, on the other hand, will cause fuse to become stiff and hard, and in this condition fuse may break when uncoiled unless warmed beforehand. After long storage, fuse becomes dry, stiff and hard. Electric squibs will withstand bad storage conditions much better and for a longer period of time than either of the others.

In first cost miners' squibs are the lowest, with safety fuse next, and electric squibs last. It must be kept in mind, however, that, as has already been said, the first cost is not a true indication of what the ultimate cost will be. The other factors are all in favor of electric squibs.

Detonating Dynamite.—Four methods are at present in use for detonating dynamite: the blasting cap in combination with safety fuse, the electric blasting cap, the delay electric blasting cap, and the delay electric igniter in combination with the blasting cap. To these may be added Cordeau, which is a "detonating fuse," but whose cost is so high as to preclude its use in anything except deep well drill holes or similar projects where very large charges of explosives are contained in a single hole. Hence it will not be considered in this instance.

Consideration of these different methods on the points constituting the ideal, reveals the fact that, with the same strength of blasting cap, they are all about equal in securing the full energy from the charge of dynamite in the hole.



Careless Tamping May Kink the Fuse and Cause a Misfire.

With the blasting cap and fuse, it is possible to fire almost any number of holes in succession or rotation. This is a most desirable feature in sinking shafts or driving tunnels, but it is impossible with this method to explode a number of holes simultaneously so that the charge in one hole will aid that in the next. With electric blasting caps, however, it is possible to fire a large number of holes simultaneously and to have each charge aid the other. This reduces, to a certain extent, the amount of explosives necessary. Furthermore, in using either electric blasting caps or delay electric blasting caps, it is possible to fire three successive series of holes in rotation, with one application of the current and without coming back to the breast or scene of the shooting. By using delay electric igniters with blasting caps crimped to the end in combination with electric blasting caps, almost any number of holes may be fired in rotation.

The blasting cap and fuse method is undoubtedly lowest in freedom from misfires, for in addition to the possibility of a misfire due to the fuse alone, there is the added risk that some moisture may enter the cap and cause a misfire. This possibility could be eliminated by water-proofing the crimp.

Electric blasting caps are as free from misfires as are electric squibs. The delay electric blasting caps, which are self-contained units, are of equal value in this respect. The delay electric igniter to which a blasting cap has been crimped probably ranks, with respect to freedom from misfires, between the electric blasting cap and the blasting cap and fuse, for there is a possibility of water's entering the crimp and causing a misfire.

As far as the blaster's safety is concerned, the blasting cap and fuse method is the most unsafe of those mentioned, because it sometimes happens that fuse will smoulder along for a considerable time and then reignite the powder train, turning what appeared to be a misfire into a serious accident. Again, when lighting a considerable number of shots in rotation, the blaster sometimes fails to make allowance for the time required to do the lighting and get to a place of safety. An accident is often the result. Another disadvantage is that the blasting cap must be crimped to the end of the fuse. This in itself presents an element of danger. The same thing is true of delay electric igniters, to which a cap must also be crimped. The electric blasting cap and the delay electric blasting caps are complete in themselves, and are, therefore, free from a similar hazard.

With the electrical method, the blaster can be in a place of safety before attempting to fire the blast. If, upon the application of the current, the blast does not follow, he can safely return and investigate the trouble, allowing, of course, a few minutes if any delay electric igniters are used in the blast.

As far as the effect of poor storage is concerned, blasting cap and fuse and the delay electric igniter and blasting cap are about on a par. Blasting caps themselves require protection from moisture, and the fuse in both cases requires similar protection. Electric blasting caps and delay electric blasting caps, being better protected from moisture by the filling in the copper shell, are not open to as strong objections on this point. They are also not affected by ordinary atmospheric warmth or cold weather. In first cost, the blasting cap and fuse would probably be the lowest, although there is a point at which a given length of fuse would equal the cost of electric blasting caps under certain conditions. The electric blasting cap is a little more costly than cap and fuse. The delay electric igniter comes next, and the delay electric blasting cap is the most expensive of all in first cost.

Summarizing the points mentioned above, the electrical method would undoubtedly be placed first, both for igniting blasting powder and detonating dynamite, in everything except first cost, and as the first cost might very easly be increased a hundred-fold by the amount of explosives lost through misfires or the cost of a single major accident, the conclusion is irresistible that the electrical method of setting off blasts is far superior to any other yet devised.

CHOICE OF METHODS FOR FIRING BLASTING POWDER.

Points to be considered.	Miners' Squibs.	Safety Fuse.	Electric Squibs.
Full energy from explosive	3rd	2nd	1st
Freedom from misfires	3rd	2nd	1st
Relative safety to blaster	3rd	2nd	1st
Relative resistance to adverse storage	3rd	2nd	1st
First cost	1st	2nd	3rd

CHOICE OF METHODS FOR FIRING DYNAMITE AND HIGH EXPLOSIVES.

Points to be considered.	Blasting Cap and Fuse.	Electric Blasting Cap.	Delay Electric Blasting Cap.	Delay Electric Igniter and Cap.
Full energy from explosive	1st	1st	1st	1st
Freedom from misfires	3rd	1st	1st	2nd
Relative safety to blaster	3rd	1st	1st	2nd
Relative resistance to adverse storage	2nd	1st	1st	2nd
First cost	1st	2nd	4th	3rd

Amortization of Debt and Street Car Fares

In an address before the New York State Conference of Mayors and other city officials, Delos F. Wilcox, who may be said to be the leading advocate of municipal ownership in this country, declared that the most important difference between public and private ownership and operation of public utilities was that the private owners constantly added to their capital account, and so built up a burden of carrying charges that tended to increase the cost of the service, while the policy of municipal owners and operators, was to gradually amortize the capital invested in the business, and so decrease the carrying charges.

In commenting on this statement the June Aera remarks that Mr. Wilcox should have pointed out the close relation between the amortization of capital and the rate of fare, and goes on to say:

Electric railway companies have in the main but one source of revenue, the fares received from the passengers they carry. Payments into sinking funds must come from the fare. The question that presents itself is the extent to which the fare of passengers in this generation should be increased in order to decrease the fare to be paid by the passengers of the next generation.

If the debt of the Glasgow Municipal Railway has been wiped out, as pointed out by Mr. Wilcox, it is evident that the car riders, who have in the past used the system, contributed in increased fares to the car riders of the present generation.

The amortization of the debt of the Glasgow Railways was rather a question of the ability of the system to charge a rate of fare that would permit of its extinction, than a question of municipal or private ownership. There are few private owners who would not hail with delight the opportunity to amortize their debt through payments made possible by rates of fare high enough to provide the cost of the service, plus the reduction of the debt.

To prescribe the proper balance between fares to be paid by the present generation for the benefit of succeeding generations and the fares to be paid by succeeding generations for the benefit of this generation is an exceeding complicated and delicate task. The point raised by Mr. Wilcox involves this and nothing else.

Various Uses of Tie Tamping Outfits

Mr. Walter P. Burn, writing in the Railway Maintenance Engineer, presents some illustrations of the use of tie tamping outfits on railroads for purposes other than the tamping of ties. As is well known, the pneumatic tie tamper has been in service several years and has proven its economy and efficiency where the cost of labor has been steadily advancing. The following data are abstracted from Mr Burns' article.

Two railroads, the Central of New England (a subsidiary of the New York, New Haven & Hartford) and the Chicago, Milwaukee & St. Paul, have simultaneously and independently worked out a method of using the air compressor of the tie-tamping outfit for the drilling of rails for bonding, and there are several points of similarity in the two methods The principal resemblance is in the employment of an "old man" for holding the drill up to the rail and feeding it into the hole as it drills.

On the New Haven line a compressor car of the size known as the four-tool tie tamper car is used. The air supplied by it is sufficient to operate four pneumatic drills simultaneously, the No. 5 Little David tool being the one used.

A crew of six men is required. The "old man" consists of a pair of iron bars, placed parallel and hooked at one end to clamp over the rail; the other end is bent downward and riveted to an angle, which is in turn fastened to a short piece of plank which rests on the ground.

The drill is supported on a pair of grooved supports which slide freely back and forth along the bars on either horizontal portion, and is fitted with a short rack in place of the usual feed screw or spade handle. The latter engages with a gear which is supported in a bearing resting on the plank and has a long handle attached to it.

The size of the hole drilled by the outfit described is 9/32 in. and the holes were made through the web of a 100-lb rail, the thickness of which is 9/16 in. An average of 70 holes per hour per drill has been made with the outfit, which includes the time occupied in moving from one position to another. The above average does not take account, however, of the time consumed in moving the tie-tamper car from one position to another, nor of the delay caused by passing trains. With each drill equipped with 100 ft. of hose, it was found that the drilling of a mile of double track required about 15.8 hours, not considering time lost due to passing trains.

On the Chicago, Milwaukee & St. Paul the rails were bonded to carry a current of far greater amperage. It is, moreover, a single track line and uses a lighter rail, so that the conditions represented differ considerably from the eastern road. On this work two drills were used with the air supplied by a four-tool tie tamper compressor car. Since the traffic is comparatively infrequent, the practice is to keep the compressor car moving along ahead of the drills, and two men are included in the gang to push it and attend to the compressor. The pace is obviously too slow to admit of running the car along under its own power. The outfit averaged 1,000 rail bond holes per day and is followed up by another gang doing the actual bonding of the rails.

Drilling rails for electrical bonding is only one of many uses which have been devised for the portable compressor car on railroads. Jackhammers have often been used with the tie tamper compressor cars for drilling rock for blasting. Boulders are easily broken up by drilling holes in them with the jackhammer and inserting a small charge of dynamite.

In the repair and maintenance of steel bridges rivets have to be knocked out, the holes re-reamed and new rivets placed. In this operation the compressor car supplies air for the riveting hammer, the drill and the forge used to heat the rivets

Where a railway track occupies a paved city street it has been found that the tie-tamping tool, when fitted with a suitable chisel, is perfectly capable of cutting either asphalt or concrete pavement. The same tool may also be used for toothing out paving blocks, but as it is unnecessarily heavy and powerful for this task, a chipping hammer is generally used. For cutting concrete pavement, a pneumatic tool known as the concrete pick is often used, but the tie tamper may also be used for this purpose where available.

The car also finds a use when the pavement is being replaced, for air may be furnished to a sand rammer, a tool which has been found to be excellent for tamping backfill. Or in the case of having to repair leaks in a pipe line, the air is supplied to calking hammer for calking the joints with lead wool, and used afterward for tamping the fill around the pipe.

A comparatively new use for the tie tamping tool on railways is that of adzing ties in place. For this the gasoline self-propelling car is used on steam railroads. The electrically-driven car is used on some electric roads, but is designed to take its power from the trolley wire, and is not self-propelling.

All the machinery is enclosed in a steel housing mounted on the trucks, and on which the sides fold up out of the way in a manner similar to the hood of an automobile. At each end of the car is a platform designed to carry the men and equipment. The truck is four wheeled and is equipped in addition with four small auxiliary wheels running at right angles to the track. These are for the purpose of removing the car from the track.

The car, when running at its full capacity, consumes about 2½ gal. of gasoline and ½ pt. of mineral oil for lubrication purposes per hour. The matter of upkeep and repairs seldom exceeds $75 for a season. The New York Central has tabulated data on some hundreds of these machines which were used in tie tamping, covering a period of five years, and has estimated that the saving afforded by their employment for that use is about $140 per mile of track tamped. This figure covers every item of cost, including the depreciation on the investment. No similar figures are as yet available on the new uses to which the machines have been put.

Railway Standards

Mr. C. A. Morse, Director of Maintenance, U. S. Railway Administration, in a discussion of a paper by Mr. F. L. Stuart before the American Society of Civil Engineers, takes occasion to correct an impression easily gained from Mr. Stuart's paper with regard to standardization, namely, that the Railway Administration is engaged in an attempt at standardization of all manner of railroad necessities and methods. This, Mr. Morse states, is untrue, and that whereas during the war there were numerous committees at work under the War Industries Board in an attempt at some general standardizations, even this work was stopped as soon as possible after the armistice.

Continuing the discussion, Mr. Morse calls attention to the fact that without doubt there are many things that could be standardized with advantage to everyone. One of the most important of these is standardization of rail sections, and of the location of bolt-holes in rails. At present, there are nearly 50 different sections of rail between 70 and 136 lb. per yard. Notwithstanding the fact that the American Railway Association and the American Railway Engineering Association have recommended as standard only seven sections between these limits, practically every railroad has a different spacing for bolt-holes, and there is a great variation between the location of the center of bolt-holes as regards the neutral axis of the rail. Standardization of rail sections and of the drilling of rails is a very desirable thing to accomplish.

The fact that the standardization of methods and appliances has been found to be a source of economy on the larger railroad systems, thereby reducing the stock of materials necessary to be kept on hand, plainly indicates that, could this be extended to the railroads of the country, it would mean economy in manufacture, which, in the end, would mean reduction in the cost to the railroads and the public.

There is no reason why standardization should, in any degree, limit efforts to improve devices or to adopt new standards at any time when an improvement in a standardized article has been perfected.

Municipal Street Railway Operation in Tacoma.—According to an official report issued by the city of Tacoma last May, the municipal street railway of Tacoma, Wash., was losing approximately $300 a day. Since taking over the lines in January, a total deficit of $40,403 was shown on the city's books.

Equipment for Detonation of Explosives by Electricity

The experience of the Army in the recent European war brought out certain weaknesses and faults in the equipment used in electric blasting and led to the development of apparatus which, it is hoped, will find a permanent place in the commercial field. In a recent issue of the Engineering and Mining Journal, Capt. L. D. Rowell describes certain features of the blasting problems as affecting general practice in the use of electricity for the detonation of explosives. We quote from his article as follows:

Electric Detonating Caps.—The standard electric caps manufactured in this country are thoroughly dependable if handled with intelligence and, when one considers their construction, their uniformity is remarkable. A current of 0.4 amp. will fire some caps, and 0.5 amp. may be depended upon to fire any single cap. The time required to produce detonation, however, varies from 0.05 sec. to 0.2 sec., even with caps of the same resistance, and may vary considerably more. This fact is of the utmost importance in electric blasting.

The variation in time required for detonation at low current strengths is not due to avoidable variations in manufacture. The effect of time variation at low currents is seen only when two or more caps are connected in series. If a current of ½ ampere be used, and two caps be connected in series, it is probable that one of the caps will fire and open the circuit before the other has reached the firing temperature, and if a circuit of 20 or 30 caps be connected up, a current of ½ ampere may fire only a few caps for this reason, even though the same current, if continued, would have fired all of them. The conclusion that the unexploded caps are faulty is entirely wrong and is based on a lack of knowledge of the true conditions.

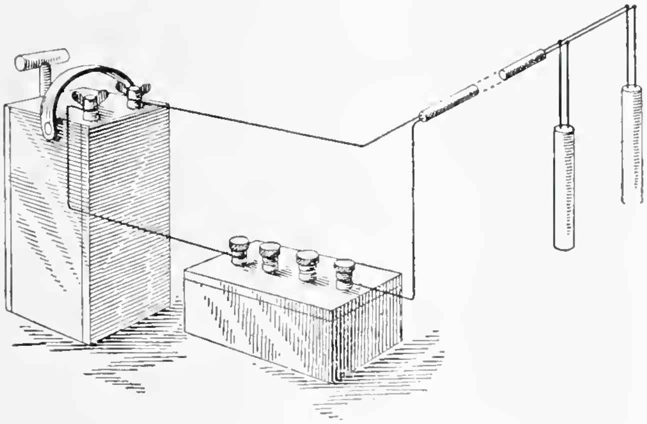
The difficulty presented by this time variation can be overcome only by using a current so high that the slowest cap in the circuit will be raised to the firing temperature before the quickest cap explodes and opens the circuit. A time interval elapses between the raising of the bridge wire to the firing temperature and the explosion, probably due to the transfer of the necessary heat from the wire to the fulminate. While this is taking place in the "quickest" cap, the current must be high enough so that the bridge of the "slowest" cap reaches firing temperature. The explosion of the first cap, and consequent interruption of current, will then not interfere with the firing of the second, as the heat transfer, which takes place in a few hundredths of a second, can proceed after the current has been interrupted. So far as I know, no accurate determination has ever been made of the magnitude of the current requird to ignite a number of caps. Experiments by Captain Ralph W. Crocker, Chemical Warfare Service, at the Pittsburgh Laboratories of the Bureau of Mines, show an increase of 20 per cent in the current necessary to fire two caps in series, one of which was 10 per cent high in resistance and one 10 per cent low. An increase of 8 per cent in current over that for single caps was found necessary where two caps of the same resistance were connected in series.

From results secured in the testing of blasting machines, I believe 1 ampere may be accepted as a safe current to insure the detonation of all caps in series. As the heating varies as the square of the current, this represents four times the heating rate required for single caps. The bridge wire fuses before explosion of the cap at a current of about 2.5 amperes, and this value forms the basis of the specifications adopted by the Corps of Engineers, U. S. Army, for electric exploders.

Testing Blasting Machines.—It is customary to test the machines by the use of a rheostat (which takes the place of a stated number of caps in the circuit), with a single cap connected in series with it. Such a test, however, may give erroneous results, for the reasons already stated; that is, the current necessary to fire a series of caps is always higher than that which will always fire a single cap. To remedy this, and provide the necessary factor of safety, the resistance of the rheostat is made two or three times that of the caps which it replaces, but this may not give the desired results, as will be shown.

The type of blasting machine in most common use delivers an initial current which is determined by the windings of the machine and is independent of the number of caps in the circuit. Now, if such a machine is designed to deliver an initial current of ½ ampere or slightly higher, it will pass a splendid rheostat test, but it will not fire a series of caps with any degree of certainty. The effect of added resistance in the circuit is to produce a more rapid falling off of current, so that a machine designed to deliver an initial current of 5 amperes may fail on the same rheostat test, and still be a dependable machine, up to its rating, though the first machine is not dependable at any rating. Making the rheostat resistance double that of the caps in the contingency suggested has not provided the necessary factor of safety. It can also be shown that, with the 5-ampere machine, doubling the resistance and using a single cap may not provide a true indication of the machine's capacity.

Rheostat Test.—The best rheostat test is to connect two caps in parallel, as shown in the figure. If they both fire, the test shows that sufficient current is delivered to insure the firing of all the caps in a series circuit. The factor of safety in such a test conforms to actual working conditions and though a difference in the resistance of the two caps may permit the explosion of both caps on less than 1 ampere, my experience warrants the belief that this is a reliable test for capacity. In making this test, be careful to place the caps so that one cannot detonate the other. The rheostat in this case should be equivalent to the actual resistance of the caps which it replaces in the circuit.



Method of Testing Blasting Machine.

The average resistance of a Du Pont cap with 10-ft. leads is 1.3 ohms, and if 1.5 ohms per cap is used in the rheostat it allows for the resistance of the cap and connections, when properly made. Duplex firing wire has a resistance of one-half ohm per 100 ft., or 300 ft. is equivalent to one cap. Allowance for this should be made in calculating the number of caps in the circuit. Thus, 25 caps connected up through 1,200 ft. of duplex firing wire would be equivalent to 29 caps. The Du Pont rheostats have a resistance of about 3.2 ohms per cap; when used as described above, with two caps in parallel, their rating may be increased in the ratio of 2 to 1. Thus a machine which fires two caps in parallel through the 25-cap step of a Du Pont rheostat would have a capacity of 50 caps.

Blasting Machine.—The blasting machines in common use frequently referred to as magnetos, or magneto exploders. This is a misnomer, and the term should not be used, inasmuch as it conveys a wrong impression as to the nature of the machine. These machines are electric generators of the series type; that is, the field windings are in series with the cap circuit. When such a machine is operated with no connected circuit, severe insulation strains are produced, and in the larger capacities this becomes a vital defect. The shunt machines, however, in which the field windings are connected in parallel with the cap circuit, do not have this objectionable feature, and they may be designed for larger capacities than is practical in the series machine. The Du Pont No. 6 is an example of this type.

By the use of small, enclosed-frame machines, with impregnated windings, exploders having considerably greater capacities than those in present use have been built and tested. Machines having the size and weight of a 30-cap exploder have a capacity of 120 to 150 caps, and a machine having a capacity of 500 caps weighs not over 35 lb. and is entirely practical. These machines represent a development in advance of any of the earlier machines, and indicate the possibilities in this field.

Testing of the electric-cap circuit is usually of the crudest sort, consisting of a test for continuity made with a "circuit detector," which is some form of galvanometer, with a self contained silver chloride cell. This type of cell is used because its potential is so low that it does not give enough current to explode the cap, and also because of its supposed permanency. This latter quality, however, is questionable, and there is nothing more undependable than a cheap circuit detector equipped with a silver chloride cell.

The best instrument of this type is a well made, pivoted galvanometer, with a graduated scale. With a good cell, and careful usage, such an instrument serves the purpose of tests for continuity of the circuit, and gives a rough indication of the number of caps. Instruments of the annunciator type, which merely show whether the circuit is open or closed, are not recommended.

For military operations, and for commercial work where it is important that there shall be no failures in the explosion, especially in cases where the cap circuit is connected up for some time before being detonated, it is highly desirable to make more thorough tests than those above indicated. For this work an extremely rugged, portable ohm-meter has been developed, by means of which the resistance of the circuit can be instantly measured, with an accuracy sufficient to detect the shorting-out of a single cap. With it, tests for opens, short-circuits and grounds can be made readily. As it uses an ordinary flash-light cell, which is easily renewable, it is not subject to the uncertainty of instruments using silver chloride cells. Protection against currents high enough to explode the caps is secured by a resistance combination, and the sensitiveness of the instrument is such that the actual current used is less than that of the ordinary circuit detector, being limited to 2 per cent of that required to explode the cap. With such an instrument, the condition of the cap circuit may be fully determined at any time, and the development of trouble at once detected.

Blasting Out in Boat Basin and Channel

A canal basin, 14x50 ft. in area and a connecting channel were constructed in the Mogothy River near Annapolis, Md., by the following method: The center line of the proposed channel was first staked out. Starting at the farther end out in the river where the water was about 2 ft. deep and the bottom composed of about 10 in. of sand with heavy black mud underneath it, cartridges of 50 per cent straight dynamite, were picked down into the mud following the center line of the proposed channel. They were put down into the mud about 18 in. and spaced about 15 in. apart. A cartridge containing an exploder was put down about the middle of the line. The firing of this charge was sufficient to set off the charges on either side down the line both ways. The method of loading was the same up through the 30-ft. stretch of marsh to the edge of where it was proposed to locate the basin. This shot resulted in a channel about 3 ft. deep; that is, giving 5 ft. of water out into the river where the depth had been but 2 ft. and 3 ft. of water up through the marsh to the edge of the basin. The basin itself was blasted by loading two parallel rows of holes 2½ ft. apart and loading a half pound of 50 per cent straight dynamite in holes spaced 15 in. apart in the row and about 20 to 22 in. deep. There was an exploder in the cartridge loaded in the center hole of each of the two rows and as it was important to have the two shots go exactly simultaneously, electric blasting caps were used connected together by the wires and the shots fired with a blasting machine. The result of this blast was a basin 14x50 ft. in area. The entire job was done with 75 lb. of 50 per cent straight dynamite and six electric blasting caps. The work consumed 2½ hours and the total cost was $45. The work was done by P. Y. K. Howat, Contractor, Baltimore, Md.

Accidents from Operation of Steam Shovels and Cranes.
A total of 226 industrial accidents resulted from the operation of steam shovels and cranes in California in 1917. Of these injuries 10 proved fatal and 15 caused permanent disability. The sum of $28,453 was paid out in compensation benefits.

The Air Receiver*

By FRANK RICHARDS.

An air receiver connected with an air compressor would seem to be about as simple a thing from the engineer's viewpoint as can well be imagined, and yet there are many things which might be said, and some which should be said and reiterated, concerning it, its function and relations as essential to be borne in mind in the interest of correct and profitable practice.

The first detail to be specified concerning an air receiver for any given service is as to its size or volumetric capacity, in which particular it is at once as different as possible from a steam boiler; for while there are rules and formulas innumerable to determine the capacity of the latter there are no such rules for an air receiver, and in the nature of things none could be expected. If we were called upon to suggest a rule for air receiver capacity we would say, have it as big as possible, and even then its size would not be of much help.

Comparative Capacities of Receiver and Compressor.—Say that we had an ordinary single-stage air compressor with an air cylinder 24-in. in diameter running at 400 ft. per minute piston speed. Its free air capacity would roughly be about 1,200 cu. ft. per minute, and its delivery at 6 atmospheres or 75-lb. gage (after the air was cooled) 200 cu. ft. per minute. An air receiver 5 ft. in diameter and 10 ft. long which would be fully as large as would ordinarily be provided for such a compressor, would have a capacity of 196 cu. ft., only 164 cu. ft. of which, at 75 lb., would be in excess of the normal atmosphere content of the receiver, so that the total receiver capacity would be decidedly less than one minute's output of the machine. With the air not cooled, as would be the case, the deficiency would be still greater.

With a two-stage compressor of the same free air capacity and compressing to 8 atmospheres, or, say, a little above 100 lb., gage, and the air at least partially cooled, the receiver capacity as above would more nearly approximate the one minute output of the compressor. But the futility of installing the air receiver for storage purposes, besides its necessarily insufficient capacity, lies in the fact that the pressure of the contained air falls immediately with any withdrawal of the air, or, if in continuous operation, whenever the output exceeds the intake.

It happens that wherever compressed air is employed for operating rock drills, pneumatic tools, hoists or other devices, the call for the air is irregular and intermittent, and the problem of maintaining a constant pressure is a difficult one, and yet one of great importance. An obvious method, and perhaps the first to be thought of, would be to have the compressor capacity approximately equal to the maximum demand, and then to trust to the safety valve to dispose of the surplus when the air consumption fell off, but that of course would be crude and costly. Automatic speed regulation of the compressor usually does not give a sufficient range, and the fractional unloading of the air cylinder is more or less of a makeshift character.

Constant Pressure in the Receiver.—By the aid of static water pressure, which is usually available or can easily be provided, a constant pressure may be maintained in an air receiver whatever the fluctuation of its air content may be, of course within the limits of its capacity, and wherever there is any permanency of installation the arrangement should be adopted.

The bottom of the receiver, the vertical type being preferable but not essential, is connected by a pipe of suitable size with an elevated body of water, either a tank provided for the purpose of capacity greater than that of the receiver, or any existing body of water whose surface is at the required elevation. It will be seen that with the receiver partly filled with water and compressed air above it the air pressure will be determined and maintained by the height of the surface of the water in the tank above that of the water in the receiver. Thus, for a pressure of 50 lb., gage, in the receiver, the elevation of the water in the tank should be 107 ft., and correspondingly for any other pressure. There is free communication between receiver and tank, and as the volume of air in the receiver decreases or increases the water in the receiver will rise and that in the tanks will fall, or vice versa, to correspond, and no water is consumed or wasted. With the water thus freely flowing back and forth a very slight difference of air pressure in the receiver will occur on account of the varying differences of height of the two bodies of water, and, singularly, the pressure will be the greatest in the receiver when it contains the greatest volume of air and when the water level there is the lowest. With compressors in operation and a constant flow of air passing through the pipes, the air which is being used need not enter the receiver at all if only a free communication between the tank and the receiver is maintained to keep the constant pressure.

The original and most notable employment of this principle was by Bruno V. Nordberg, by whom the arrangement has since been patented, at the group of mines of the Anaconda Copper Co., Butte, Mont. Here a battery of air receivers connected with a large tank of water at the required height maintains a constant pressure of 90 lb. gage, so that the entire compressing system, with a free air capacity of 20,000 cu. ft. per minute, might be stopped for half an hour and the full air pressure maintained, against maximum consumption.

Air Receiver Construction—The normal air receiver of the present day is a cylindrical steel shell of a length two or three times the diameter, and often much longer than that if used horizontally, with bumped heads riveted in. When the receiver is large enough to have a manhole both heads are usually inserted with the convex faces of the heads outward, as they should be, but for the smaller receiver the generally accepted custom has been to have one head as it should be and the other head as it should not be, or with the concave face of the head outward, just for the convenience of the riveter in manufacturing, a thing for the mechanical world to be ashamed of. The later developments of welding processes remove the last excuse for receivers so constructed, and, indeed, we may hope to see rivets entirely discarded in air receiver construction.

Every air receiver before being put into service should be subjected to a hydrostatic test to a pressure considerably above that to which it will ever be subjected when in use, and in determining what shall be the test pressure limit it will be well to consider that working conditions are more strenuous than the quiescence of the shop. There is liable to be more or less shock or jar, and especially there are possiblities of a great range of temperature changes, and also in course of time the receiver will be weakened by rust, all of which particulars should be allowed for, with an additional factor of safety above that.

Explosions from Static Pressure.—The subject of air receiver explosions is an interesting and important one; and first of all we need a discriminating definition of the word "explosion," for so-called explosions of air receivers occur under two entirely different sets of conditions and with differences of result and consequences which are almost incomparable.

First, there is the letting go of the receiver and the sudden escape of the air when its pressure at the moment is greater than the material of the receiver can withstand, all other conditions being presumably normal. The air pressure from some cause may have become greater than ever before, or the receiver may have been insidiously weakened. With so small a margin of safety as has usually been deemed sufficient it is little wonder that these static pressure explosions should occasionally occur. When such an explosion does take place, the results to the surroundings are usually much less serious than when a pressure explosion of a steam boiler occurs, because there is nothing but the confined air to escape, while in the steam boiler there is not only the actual steam in the space above the water, but this is followed up by more steam instantly generated from the hot water and also frequently this is backed by the rush of masses of the water itself.

Explosive Ignitions.—The fixing of working pressure limits, the safety valves and other precautions which should be provided, guarantee only immunity from explosions of the preceding type, and are of little account when there occurs the firing of an explosive mixture of air and oily vapor within the receiver or its connections. Concerning explosions of this character there is much more to be said, and investigations of causes must have to do with much more than with the receiver itself. We must begin in fact with the beginning of the air compression, and even outside the compressor where the man in charge doses the machine with the lubricating oil; for in the use of the lubricant in the compressor lies either danger or safety, and much which has to do with the ultimate economy and safety of the entire compressed air system.

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*From Compressed Air Magazine

It is encouraging to be able to note that the troubles attributable to the lubricant used in air compressors have been greatly reduced, especially when the vast increase in the number of compressors and in the volume of air used is considered, and perhaps we may more readily comprehend why this is so by comparing what might be called the ancient and the modern styles of practice in air compression. These lie not farther apart than a single generation of men, with no distinct demarkation between them, so that there are still survivors of the primeval to discredit the present.

The Ancient Air Compressor.—The typical compressor of the earlier type which we here have in mind, supplying air mostly to rock drills in mine or tunnel, was a single stage machine compressing the air, to say, 90 lb. gage, without any cooling devices for the air, and little thought was given to the effects of the presence of the lubricant except for the actual lubrication, and, as a consequence, the oil was used "liberally." Now, the oil which is fed into the air cylinder has no discharge or escape except into the air itself by which it is caught up and carried along. At the point of its leaving the cylinder and immediately thereafter the heat of the air is sufficient to decompose the oil and leave the carbon to accumulate as a black sticky mess of combustible material lining the air passages and the interior of the receiver, while the more volatile constituents of the oil are carried along by the air to wherever it is finally discharged. As to the latter, there is an authentic court record that a man in an Alabama coal mine was fatally asphyxiated by the oil fumes in the exhaust of an air driven steam pump, and heavy damages were collected.

Under the system of high pressure, single stage compression which formerly prevailed it was undoubtedly necessary to use much more oil than in these days when such high temperatures and undivided pressures are avoided, and with the extravagant use of lubricating oil above spoken of the carbon deposit accumulated rapidly in the air receivers, and it was a frequent occurrence to have the material take fire and burn with such sudden fierceness that the receiver became visibly red hot. It may have been the products of combustion resulting from such a fire that asphyxiated the miner spoken of above.

It is not worth while to inquire how ignition could occur in such a case, as the heat of the compression and the presence of six times or more the quantity of oxygen per volume of air would alone be almost sufficient to account for it. The stopping of the compressor would of course stop or smother the fire at once for lack of fresh air.

Receiver explosions in connection with such fires did not generally occur. In one case there was a vertical receiver with the convexity of the head facing inward, and when the fire occurred the pressure of the air reversed the curve of the head and the receiver was lifted entirely clear of its support. Another receiver, horizontal, actually seen and photographed, after the event, by the present writer, about 2 ft. in diameter and 5 ft. long, had a similar concave head which became red hot and while hot was reversed by the pressure, the reversal occurring with such a snap that the head was torn out entirely clear of the shell.

Two-Stage Compression.—So much for the ancient and obsolete or obsolescent practice. The modern way is to have two-stage compression for the ordinary working pressures, say from 5 to 8 atmospheres, with efficient cooling of the air between the stages. By this arrangement the high temperatures are avoided, the oil has better lubricating effect, it retained longer upon the friction surfaces and less oil is required. More intelligent and careful supervision also is exercised as to the systematic feeding of the oil, and, as an essential detail, careful records are kept.

It might appear in the light of present, up-to-date practice that the function of the lubricant in the air cylinder is not altogether clear. The impression has been that more or less oil must always be present upon the friction surfaces. This belief is not easy to retain in the face of some indisputable records. On the Panama Canal work the tabulated records show 1,887,513 sq. ft. of cylinder surface swept by the piston per pint of oil used. This area is about 40 acres, and cannot imagine a pint of oil could be made visible or otherwise discoverable if spread over such an expanse. A compressor of the Nevada Consolidated Copper Co. has more recently shown a rate of lubricating oil consumption only one-third of the above. At the present time there is more or less discussion current, which we will not here go into as to the quality of the oil most suitable for air compressors, our impression being that quantity rather than quality must be the determining characteristic. It is neither high flash point nor low flash-point, but, rather, no flash point that will guarantee absolute safety.

Moisture in the Air.—In dealing with compressed air in any way the problem of disposing of the moisture contained in the air is practically always encountered and imperatively demanding solution. Air taken in to be compressed free air, is never so dry that it does not prove to be super-saturated after being compressed to five or six atmospheres and allowed to cool to normal temperature, and the air receiver has been popularly regarded as an important agent in disposing of the surplus moisture, but for that service it must be regarded as more or less a disappointment.

The Work of the Intercooler.—To fully appreciate the possibilities and the impossibilities in connection with the air receiver and its attributed functions it may be well to consider the practical operation of the intercooler of the two-stage compressor. Without the intercooler there would be no reason for and no advantage in two-stage compression. The primal argument for the intercooler is that it reduces the volume of the air under compression, leaving less work for the high pressure cylinder and thereby saving power. It may as well be conceded that this result alone would scarcely be sufficient to enforce the general adoption of the intercooler, its incidental services being really of more practical value than the mere saving of power.

The reduction of volume effected by the intercooler is merely a consequence of the reduction of temperatures, but the reduction of temperatures is in itself a great good accomplished. The deposition of the carbonized residuum of the oil upon the valves and in the air passages is greatly reduced and the spontaneous ignition of the oily deposits or the firing of explosive mixtures which might be formed is rendered practically impossible. The lubricating oil also remains in better condition and lasts longer upon the friction surfaces, so that less oil is required.

Condensing the Mixture.—The cooling of the air in the intercooler for the primal purpose of reducing its volume also provides the conditions most necessary for the separation and extraction of the moisture carried by the air. Up to the point of complete saturation of the air, the water carried by it and which in greater or less quantity is always present, is in the form of steam. Not steam under the conditions with which we are most familiar with its boiling point at 212°, but yet true steam. We must remember that under varying conditions water may have its boiling point and its point of recondensation anywhere either above or below 212°. It is true steam carried by the air and normally with all the accompanying phenomena of true steam, and the water can be eliminated from the air not by any process of straining or filtration, but, first by the condensation of the steam and then by the deposition and collecting of the water of condensation. Any intercooler is thus a condenser and might properly be so called, whatever its construction, so far as it accomplished the purpose of converting into liquid the vapor that is mixed with the air.

Very roughly stated, the capacity of air for moisture at the saturation point and at any constant temperature is directly as the volume, or inversely as the absolute pressure. Thus, with free air at 50 per cent of saturation, and it is generally above rather than below that, it will, at the same temperature, be completely saturated when its absolute pressure becomes 2 atmospheres, or, say, 15 lb. gage, and its volume is reduced to one-half.

But it is to be remembered at the same time that the capacity of the air for moisture is much more rapidly affected by changes of temperature. As a general rule this capacity is doubled with each rise of temperature of 20° F. Thus, in the case just cited, when the air theoretically became completely saturated, so far as the pressure alone was concerned, when a pressure of 2 atmospheres was reached, the operation of raising the pressure of the air by 15 lb. at the same time raised its temperature more than 100 degrees, so that by this rise of temperature the moisture carrying capacity of the air was increased 2x2x2x2x2, more than 32 times.

It will thus appear that the air which comes to the intercooler after its compression in the low pressure cylinder is, on account of its high temperature, in an extremely "dry" condition, although its actual water content has not been reduced in the least. It is so dry in fact that the proposition to relieve it of some of its contained moisture seems almost absurd. And yet, assuming the aftercooler to be properly designed and equipped for its purpose, the parting of the water from the air begins quite early in their transit through the apparatus, and continues with increasing rapidity and until the cooling of the steam-and-water mixture is completed.

The typical intercooler might be any air receiver in which have been mounted a great number of thin metal tubes of small diameter so connected that they are all constantly full of cold water in active circulation, the air which is to be cooled filling the body of the intercooler and surrounding the cooling tubes, it being provided that, by means of baffle plates or otherwise, this air also is constantly in motion along the surface of the tubes, or preferably across them with impinging action. It is further arranged that the final emergence of the air from the intercooler is at the end where the cold water enters, thus insuring that the air as it leaves the intercooler shall be at the lowest temperature possible, and little above that of the cold incoming water.

The Condensation of the Water Vapor.—The cooling action which takes place in the intercooler, when considered in detail, is not at any instant operative upon the entire body of the air at the time contained within the intercooler, but upon successive films of the air which come immediately in contact with the surfaces of the cooling tubes, and hence we may see how the condensation of the vapor and the separation and the deposition of the water may commence immediately that the air enters the intercooler. Steam contained in the free atmosphere will be condensed and globules of water will form upon the outside of a pitcher of ice water carried into a room of normal temperature without perceptibly lowering the mean temperature of the room. In this case a very small cooling surface is presented to a large body of air which contains more or less water vapor, but yet the air immediately in contact with the pitcher is effectually cooled and some of the vapor in it is condensed. The case of the intercooler is the reverse of this. In it small portions at a time of moisture-laden air caused to flow over large cooling surfaces and the result in kind is the same, but the quantities of moisture released are much greater. As the moisture in the films of air which successively come in contact with the cold tubes is condensed and adheres to the tube surfaces the globules, at first minute, begin to grow larger and then run together to form large drops and these run down and collect at the lowest point, where means must be provided, automatic or otherwise, for removing the water.

Aftercooler as Necessary as the Intercooler.—The task, or as we see in detail, the several tasks, assigned to the intercooler may be satisfactorily and completely performed, and yet the work it does in the nature of things cannot be more than half the work of that kind requisite to be done. All that the intercooler does is still, to make the job complete, more necessary to be done after the final compression and before the sending out of the fully compressed air to do its work. An air compressing installation cannot in these days be said to fully satisfy the demand upon it when it merely puts out so much air compressed to the given pressure without regard to the condition of the air as delivered.

The air in the first place should be cooled at once as it leaves the compressor to reduce its volume and minimize the friction loss in transmission, which is a small matter in itself, but the cooling of the air secures for it the combination of conditions, highest pressure and lowest temperature, when its moisture carrying capacity is at the minimum, and advantage should be taken of this for drawing off all the water so released, and if this is not done the subsequent inconvenience, delay and other money losing details should be added to power cost and the other costs of the compression.

Those most intelligently seeking economy in compressed air practice today recognize these things. In the most up-to-date installations will be found not only the receiver, which seems to be inevitable, but also the aftercooler and the moisture separator, each individually supplementing the compressor, and all proving themselves worth while in practice. These things carry no operative expense except for the supply of water, and that is not consumed, but is still usable for any other purpose, so that a more profitable investment could not well be found.

Use of Manganese Steel in Curved Rails Not Always Economical

The use of manganese steel and other alloyed steel in special track work, including curves, upon electric railways was a rather fixed practice before the steam railroads began to take an interest in the subject. In fact it took a long time to prove to them that even a trial would prove its worth. Once convinced, the steam roads have become large users of this material for some kinds of work. Meanwhile the electric railways had gained considerable experience in comparative wear of manganese steel as against bessemer and open-hearth steel, especially in curves, and some street railway engineers were long ago bold enough to voice the results of these experiences, which were to the effect that for plain curves the conditions must be exceptionally severe to warrant the added expense of the manganese, even at the pre-war price differences. Some electric railways have found that they could afford to renew a curve three times with open-hearth steel for the same total expense as was involved in one manganese curve. The tendency in the use of expensive manganese curves is also toward permitting the curves to remain in service long beyond the time when good maintenance would call for their removal.

Similarly it was found that only in certain exceptionally severe locations was it advisable to install the excessively expensive manganese special track work. The steam roads are beginning to find out the truth of this matter also, if the reports of tests on alloyed steel rails in service in curves, as recently rendered by the committee on rails of the American Railway Engineering Association, can be taken as a guide. Here, two different railroads report that when the high cost is considered, the proposition can hardly be considered economical. It is also noted that the manganese rails become distorted more easily than bessemer or open-hearth rails, an observation which confirms electric railway experience. In fact, in electric railway service, the distortion has been the real cause of removal in several instances, rather than direct abrasion. Similarly, in special work for steels in many cases so-called soft centers (medium-steel or sometimes cromium-steel) will serve the purpose better than manganese at less cost.

The lesson to be learned from these combined experiences points out the Electric Railway Journal seems to be that a very careful study of conditions should be made before a decision is had as to the advisability of substituting manganese steel in curves and other special work, since it will often be found that some other alloy-steel or even open-hearth steel will eventually prove more economical.

Salvaging Track Material with Sand Blast

According to the Electric Railway Journal, the United Railways of St. Louis are meeting with much success in making available for reuse quantities of old track material, especially screw spikes, joint plates and bolts.

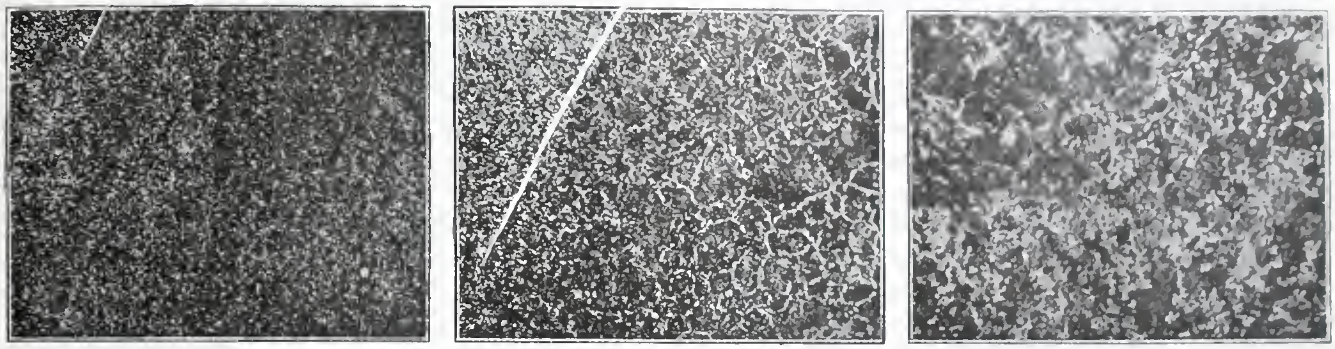
The screw spikes, when removed from old track, have usually parts of the old ties adhering to them, but a short treatment with the sand blast cleans them perfectly and after being dipped in oil they are ready to use again. Fish plates require no treatment other than the sand blast.

Nichols' joints are taken out of the track by cutting the rail on each side of the joint near the end of the plate. The plates are then taken into the yard and the rivets knocked out with a pneumatic hammer with a long stroke, called a pneumatic "gun." The spelter is easily knocked loose from the plates and is then ready for remelting.

The company tried various ways of operating the sand blast, particularly with bolts and screw spikes which are so small that they could not easily be set up against a board. Finally the best way was found to be to put the bolts and screws in the hoppers of some old dismantled wheelbarrows so that they roll around as the sand blast plays on them.

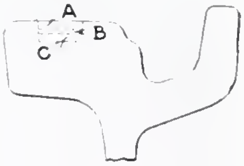
Sorbitic Treatment for Rails

The sorbitic process of hardening rail surfaces, invented by Mr. C. P. Sandberg of Great Britain may be applied either to new rails at the mill or to those already in place in the track without disturbing the pavement. As described in the Electric Railway Journal, the method consists, when applied at the mill, of subjecting the rail heads, as they come from the hot saw at a temperature of about 900° C., to a blast of air at 15-lb. pressure from a series of discharging nozzles. When applied to rail already in place, the lead is heated by oxy-acetylene flame and immediately quenched by water jets.


A B C

Microphotographs Showing Gradual Change of Structure in Rail Heat Treated by Sandberg Process

In a demonstration conducted for the benefit of a representative of the above mentioned journal, a length of rail was subjected to the flames from a specially designed twin or duplex oxy-acetylene blow pipe, mounted on a light hand-propelled, geared truck, which advanced at the rate of about 1 ft. per minute. The rail surface was raised to a red heat and immediately quenched by means of water jets, close to and just behind the blow-pipe nozzles. After the passage of the truck large, freshly-ground cold chisels were applied to both treated and untreated portions of the rail. No difficulty was experienced in notching the untreated rail, but the edges of the chisels were immediately turned up or chipped on being applied to the treated portions.



Sections from Which Microphotographs Were Taken.

Another evidence of the change in structure of the rail-head metal is shown in the microphotographs taken at different depths below the rail surface.

Number of Wagons Required for Hauling From Steam Shovels

Very little information is available as to the number of wagons required to handle the output of a steam shovel for different lengths of haul. The following data from which an approximate estimate can be made are reprinted from the August issue of Successful Methods:

YARDAGE FOR VARIOUS HAULS

Haul in ft.	Round Trips.	Cu. yd. per day per team with 1½-yd. wagons.
500	105	157
1,000	53	79
2,000	26	40
3,000	17	26
5,000	10	15
10,000	4	6

NUMBER OF TEAMS FOR VARIOUS OUTPUTS.

Daily output in cu. yd.	Haul 1,000 ft.	Haul 3,000 ft.	Haul 10,000 ft.
250	3	10	41
300	4	12	50
500	8	20	84

On a road job in Minnesota 5 wagons are serving a ¾-yd. steam shovel on a 300-ft. haul and are kept busy.

At Hamilton, O., a steam shovel with a ¾-yd. bucket, loading gravel on a 3 to 10-ft. face, loaded 480 2-cu. yd. wagons in 9 hours, and 60 teams were estimated as necessary to keep the shovel busy on a 1-mile haul. The same shovel handled clay out of a 6 to 12-ft. face and should be able to load 360 2-yd. wagons in 9 hours. This would require 45 teams to haul the material away on a 1-mile haul, 8 trips to the team.

TNT As a Blasting Explosive

TNT is an explosive which is obtained by acting upon toluene with nitric acid in the presence of sulphuric acid. It has been known to chemists since 1863 and it was adopted as a military service explosive by 1902, but it did not become widely known until the Great War, when it came to be extensively used. With the cessation of hostilities this country found itself with very large supplies of TNT on hand. So large indeed that it was deemed unwise to keep all of it in stores awaiting future military use and it was proposed to devote many million pounds of it to industrial use. Careful experiments and observations have been made by the Bureau of Mines Experiment Station to determine the value of this explosive as an industrial blasting agent. The results of this study are set forth by Charles E. Munroe and Stephen P. Howell in a bulletin issued recently by the U. S. Bureau of Mines, from which the matter following is abstracted:

TNT is more difficult to detonate with certainty than nitroglycerine, dynamite or the explosives ordinarily used in engineering operations, in mining and in quarrying. TNT charges require a No. 8 detonator (blasting cap) or electric detonator, while dynamite and the other high explosives ordinarily used in industrial operations require but a No. 6 detonator.

As shown by tests with the pendulum friction device, all the three grades of TNT are less sensitive to friction than 40 per cent straight dynamite, gelatin dynamite or picric acid, and as shown by tests with the large impact machine all are less sensitive to percussion than 40 per cent straight dynamite, ammonia dynamite and nitrostarch powders. It may be set on fire, when it will burn, but this burning may change to a detonation. Hence TNT must be protected from fire and causes of fire, such as sparks, flame, heated bodies, friction, percussion and the like, as all explosives should be at all times.

In tests made at the Pittsburgh Experiment Station by detonating TNT Grade 1, and collecting the gases it was found that 454 grams (1 lb.) of the explosive gave 506.5 liters of gases, of which 46.6 per cent, or 236 liters, were poisonous gas (CO) and 73.8 per cent, or 373.8 liters of combustible gases (CO, H and CH_4). The tests of other grades of TNT gave similar, though not identical, results, but all indicate it to be unsafe to use TNT in close places, such as underground workings and particularly coal mines. These results emphasize the importance of remaining away from the face of the blast after the explosion until assured that the gases produced have been blown or have diffused away from the interstices of the debris.

In determining the relative efficiencies of explosives in use, the Bureau of Mines has long employed the "unit deflective charge" and the "rate of detonation" as criteria. The unit deflective charge is ascertained by exploding a known weight of the explosive in the Ballistic Pendulum, and this term "unit deflective charge" is defined as "that weight of an explosive which will swing the ballistic pendulum the same distance as ½ lb. of 40 per cent straight nitroglycerin dynamite." Tests of the unit deflective charge showed each of the three grades of TNT to be 9 to 14 per cent stronger than 40 per cent straight nitroglycerin dynamite. The rate of detonation of the TNT was practically the same as for 40 per cent dynamite.

When either of the three grades of TNT are packed in cartridge cases or in bore holes under ordinary tamping pressures, the apparent specific gravity of the charges vary from 0.81 to 0.95, while when 40 per cent straight dynamite is so packed, the apparent specific gravity of its charges are from 1.15 to 1.34. It is evident, therefore, that for equal weights the TNT cartridges will be more bulky than the dynamite cartridges. As a consequence of this, larger bore holes must be used for TNT charges than for dynamite charges of equal weight. This presents an advantage for the dynamite over the TNT, but, on the other hand, it has been observed that as the apparent specific gravity of the TNT approaches the lower limit given above its resistance to wetting, when the cartridges are immersed in water, increases. Hence, it is recommended that except in assuredly dry holes, or in big blasts, where full boxes of the explosive may be fired in chambers, the TNT be packed for use in cartridges and that, as the No. III Grade is the most water resistant of them all, it be packed at a low pressure and reserved for use in the especially wet work.

The practical value of TNT, Grade III, for general blasting purposes was tried out by a number of field tests, such as adobe shots on boulders and concrete piers, blasting out oak stumps, splitting oak logs and shooting under water. The tests were loaded in extemporized wrappers, made from newspapers, and detonated by a No. 8 electric detonator. The conclusions based on these tests were: Grade III TNT can be successfully used for adobe shots of boulders, for removing stumps, and for splitting logs. It has shown itself to give results the equal of 40 per cent straight nitroglycerin dynamite. It detonates completely with a No. 8 electric detonator. The evidences of black smoke is not to be taken as an incomplete detonation. It detonates completely under water. It detonates completely after moderate immersion in wet holes.

Since some blasting must be done in damp or very wet holes, it is desirable to know the water resisting properties of the different grades of TNT when compared with such well-known commercial explosive as 40 per cent "straight" nitroglycerine dynamite and 40 per cent strength ammonia dynamite. 1¼ by 8 in. cartridges of Grade I, Grade II and Grade III TNT and the two dynamites were submerged in thoroughly wet sand in pans at room temperature for definite periods of time and attempts made to detonate each cartridge when confined in sand in a borehole. No. 6 electric detonators were used with the TNT and the dynamites. If complete detonation occurred in each of three trials, the explosive was considered as having sufficiently resisted the water.

The conclusions from these tests were: When both ends of cartridges of all grades of TNT are redipped and not punctured, they withstand water fully as well as the dynamites when tested as received. This shows the efficacy of this type of cartridge and is independent of the nature of the explosive within the cartridge.

Grade III TNT in cartridges resists water for 1 to 72 or more hours, the time depending upon the density at which packed and the nature of the cartridge. In all cases with Grade III TNT, the cartridges which were packed easily withstood the water better than those which were packed hard. Grade III TNT has very much better water resisting properties than either of the other grades of TNT, and especially so when packed easily and compare very favorably with the dynamites tested.

Of the three grades of TNT, the only one recommended for use in wet holes in cartridge form is the Grade III. The others may be used for wet work if packed in completely redipped paraffined cartridges, provided they can be charged without breaking the cartridges.

New East River Tunnel Holed Through.—Excavation work in the north tube of the 14th St. rapid transit tunnel under the East River at New York was completed Aug. 7, when Transit Construction Commissioner John H. Delaney fired the shot which holed through the last piece of rock between the tunnel headings from Brooklyn and Manhattan. By this final blast it was made possible to walk through the tunnel from the foot of 14th St., in Manhattan, to the foot of North 7th St., Williamsburg. A considerable part of the tunnel work was done under an air pressure of 39 lb. Under that pressure the men were employed in 3-hour shifts.

Principles of Service at Cost as Applied to the Solution of the Traction Problem

In a paper of some length presented at the New York State Conference of Mayors and Other City Officials, at Schenectady, Mr. Harlow C. Clark makes an analysis of the relations between the public and the traction interests, with special reference to finance. He summarizes the plan of service at cost as follows:

1. That private individuals and corporations shall act as the agents of the public in providing street railway service.
2. That such agents shall receive for their services (a) such a rate of interest upon their investment in the property used and useful in serving the public as will attract capital into the business, and (b), an additional compensation as a reward for initiative, to be measured by the economy and efficiency manifested in the management.
3. That the degree to which the street railway system shall be called upon to bear public taxes and imposts, be determined, in the light of fairness and justice as between the taxpayer and the car rider, against whom such imposts are directly levied.
4. That the cost of operating the property should be borne by the persons receiving the service, through a system of fares so adjusted as to respond to the variations in costs.
5. That the public, under such a system of fares as will provide the cost of whatever service is reuired, shall prescribe the service to be furnished.
6. That because, under the plan proposed, the rate of fare will largely depend upon the economy and efficiency with which the property is operated, the co-operation of the public in the elimination of unnecessary service and in the introduction of all proper operation economies, be enlisted.

Cost of service is not a new thing to the United States. It has been in effect in Cleveland since 1910. The Boston Elevated Ry. Co., operating in the city of Boston; the Bay State Street Ry. Co., serving the eastern part of Massachusetts; the Mahoning & Shenango Ry. Co., serving the city of Youngstown, O.; the Montreal Tramways Co., serving the city of Montreal; and the Cincinnati Traction Co., serving the city of Cincinnati, are now operated under complete service at cost plans; while the agreements effective in Chicago, insofar as the surface lines are concerned, in Dallas, Texas, Des Moines, Ia., and Kansas City, Mo., embody many services at cost features. Massachusetts has a general law which permits any street railway company complying with its requirements to put service at cost into effect. In Chicago, a complete cost of service agreement, with operation of the system by public trustees, was defeated last year by referendum. The city of Philadelphia entered into an agreement with the Philadelphia Rapid Transit Co. for the operation of the rapid transit system which the city is building under a service at cost plus plan, but the agreement was disapproved by the State Public Service Commission, the consent of which was necessary. Governor Smith has just vetoed a bill providing for service at cost for the International Railway Co., serving the city of Buffalo. In addition, the plan is being considered by a number of cities, including Denver, St. Paul, Minneapolis, Oakland and New Orleans.

These various measures differ largely as to details, but the same general theory is the basis of them all—that is, that the return to the owners shall be limited to an amount sufficient to attract capital and secure efficiency, and that the rate of fare to be charged shall depend upon the cost of providing the service and shall vary from time to time as this cost varies.

At the close of his paper, Mr. Clark summarizes also what he conceives to be the merits of service at cost, as follows:

That it establishes a method by which the price of street railway service may be brought into correct relation with its cost;

That it is applicable to all methods of operation and under control, whether directly by the public, by private corporations, or by state, or local regulation;

That it permits the public to specify the kind and extent of service to be furnished;

That it is applicable to any system of charging, either by distance, by zones or by a flat rate;

That it induces co-operation between the public and the management in securing economical and efficient management;

That it removes the antagonism between the public and the corporations furnishing them transportation service, and

That it establishes the transportation utilities as agents of the public, performing for the public a public service and receiving therefore a reasonable, a sufficient and an assured return.

National Transportation Conference Plan for Railroad Legislation

There is a striking contrast between the two typical plans for railroad legislation now before Congress—the plan of Government ownership and operation in the interest of one particular class, as advocated by the railroad brotherhoods, and the plan of returning the railroads to their owners, as urged by the National Transportation Conference and by all the other groups that have appeared before the House and Senate committees.

Briefly stated, the plan for railroad legislation recently submitted to Congress by the National Transportation Conference provides for—

1. Return of the railroads to private ownership and operation as soon as the necessary remedial legislation can be enacted.

2. Consolidation of existing railroads into strong competitive systems.

3. Requirement that all carriers engaged in interstate commerce subject themselves as corporations to federal jurisdiction.

4. Exclusive Federal regulation of the capital expenditures and the security issues of all carriers engaged in interstate commerce.

5. Interstate Commerce Commission to retain its present powers and to be given additional powers over rates.

6. Creation of a Federal Transportation Board, to promote the development of a national system of rail, water and highway transportation; to pass upon the public necessity for capital expenditures; to regulate security issues; to administer and enforce the measures that may be adopted for strengthening and stabilizing railroad credit; to determine the grouping or consolidation of railroads deemed to be in the public interest; and to carry out plans authorized by Congress for merging all railroads engaged in interstate commerce into strong competing systems.

7. Adjustment of the wages and working conditions of railroad employes by boards consisting of equal numbers of representatives of railroad employes and railroad officers, with the Federal Transportation Board as referee.

8. Adoption by Congress of a plan for the stabilization of a railroad revenues and credit by means of

(a) Enactment of a statutory rule providing that the the rate structure established by public authority shall be designed to yield a net return of 6 per cent per annum upon the aggregate fair value of the property of the roads in each traffic section of the country, such fair value to be determined after due consideration of both physical value and earning power.

(b) Use of the aggregate property investment accouuts of the railroads as the fair value of the property for rate-making purposes pending the completion of the valuation now being made by the Interstate Commerce Commission.

(c) Creation of two kinds of contingent funds an individual railroad contingent fund established by each road to support its own credit, and a general railroad contingent fund maintained by contributions from all prosperous roads, managed by trustees appointed by the Federal Transportation Board and used to support the credit of all of the railroads of the country. Any excess in the general railroad contingent fund above $750,000,000 is to be used for the general development of the transportation system of the country.

9. Creation of a railroad reserve fund administered by the Federal Transportation Board to facilitate the prompt stabilization of railroad credit; and loan of $500,000,000 to this fund by Congress as soon as the railroads are returned to their owners; the loan to be used, if necessary, in making advances to the general railroad contingent fund, and to be repaid with interest from moneys contributed by the railroads to the general railroad contingent fund.

10. Determination and announcement by the Federal Transportation Board of the grouping or consolidation of railroads deemed to be in the public interest, and authorization for the board to require such consolidations if they shall not have been effected or well advanced within a period of five have been CMRDLU SHRDL CMFWYPnw5hbfl JRrfIKRfiJJ years after the board has declared them to be desirable

11. Organization of the Board of Directors of each consolidated railroad system with 12 members of the board one to be a representative of the employes of the system nominated for such position by the employes, and three to be selected by the Federal Transportation Board to represent the principal interests involved in the territory served

The Chamber of Commerce of the United States has adopted by referendum vote seven of the above recommendations of the National Conference propositions 1 to 6 and also No. 11. The other parts of the conference program, though not included in the plan adopted by the Chamber of Commerce, are in harmony with the principles of the Chamber's plan.

Advantages of Using Stemming in Blasting

Tests were made some time ago at the Pittsburgh Station of the U. S. Bureau of Mines to determine the effect of stemming on the efficiency of explosives. Some of the results of these tests are summarized in a recent bulletin of the bureau on the mining and milling of lead and zinc ores in the Missouri-Kansas-Oklahoma zinc district.

In carrying out the tests, the Trauzl lead block a lead cylinder 7⅞ in. high and 7⅞ in. in diameter, with a bore hole 1 in. in diameter and 5 in. long was used, as it furnishes one of the simplest means for measuring the relative strength of high explosives.

A known amount of the explosive under test is placed in the bore hole and then fired. The pressure of the gases evolved by the explosive expands the hole into a pear-shaped cavity. The original volume of the bore hole is determined by measuring the amount of water required to fill it exactly; the volume, after a test, is determined in the same way. The difference between the volume of the hole after the firing of the charge and the volume before firing is taken as a measure of the force exerted by the explosive.

The different kinds of stemming used in the tests were dry sand, both tamped and untamped, dry fire clay, tamped and untamped; moist sand, tamped; and moist fire clay, tamped. Table 1 shows the effect of using different weights and kinds of stemming.

TABLE 1.—EXPANSION OF BORE HOLE IN LEAD BLOCKS BY 10 GRAMS OF EXPLOSIVE WITH DIFFERENT KINDS AND WEIGHTS OF STEMMING

Forty per cent strength ammonia dynamite: Kind of stemming.	Weight of stemming grams 0	6.25	12.5	25	50	100	200
Untamped dry sand ...expansion of bore hole, cc	230	301	359	408	430	[illegible]	[illegible]
Untamped dry fire clay "	230	288	317	385	387	381	378
Tamped dry sand "	230		355	379	393	397	417
Tamped dry fire clay "	230	255	339	382	384	373	381
Tamped moist sand "	230	265	293	375	389	419	[illegible]
Tamped moist fire clay "	230	280	311	382	[illegible]	462	487
Forty per cent "straight" nitroglycerin dynamite:							
Untamped dry sand ...expansion of bore hole, cc	367	462	501	569	587	636	[illegible]
Untamped dry fire clay "	367	460	496	571	578	590	584
Tamped dry sand "	367	454	503	591	592	615	[illegible]
Tamped dry fire clay "	367	385	501	631	602	629	645
Tamped moist sand "	367	465	525	[illegible]	645	697	[illegible]
Tamped moist fire clay "	367	507	547	623	613	696	710

According to Snelling and Hall the results obtained from the experiments prove definitely that confinement by the use of stemming greatly increases the efficiency of a charge of explosive.

As the expansion of the bore hole of the lead blocks in the experiments is a good measure of the pressure that is exerted on the wall of a drill hole by the same explosives in actual mining operations, it is reasonable to assume that the useful work done by the explosives would be in the same ratio. The results of the tests show that with quick-acting explosives, such as "straight" dynamite, a small quantity of stemming greatly increases the efficiency, whereas a large quantity is required with slow-burning explosives, such as black blasting powder, for effective results. In addition, the use of stemming reduces the evolution of poisonous gases to a minimum.

MANAGEMENT AND OFFICE SYSTEM

This section is published twice a month: (1) In the Waterworks and Hydraulic Monthly issue, and (2) in the Railway and Excavation Monthly issue. It covers what may be broadly termed "management engineering" as applied in the civil engineering and construction fields.

Accounting on "Cost Plus" Contracts

By RALPH W. HORNE.

Although the "cost plus" form of contract for construction work is not a novelty, it has been more extensively used during the past two or three years, than was formerly the case. Its use for most of the emergency was construction work, carried out by the United States Government, produced physical results which were very satisfactory, although the costs in some instances may have been high. For private work it has frequently given even better satisfaction as more time has been available for applying efficient methods to obtain low cost work; the rapidity of construction being a less vital factor.

An engineer or artichtect having supervision of private work under this form of contract, finds that his oversight must cover not only proper inspection, from the structural view point, but also the keeping of accurate cost records, in order to properly safeguard the financial interests of his client, the owner. This cost keeping phase of the work has too often been neglected; but with the recent increase in prices for both labor and materials it is highly important that economy should be the watchword in all future construction undertakings.

Upon the completion of a project the party having supervision of the work should be able to account to the owner for the use of all labor and supplies (both material and tools), which have been charged to the job and should be able to show that all such have either been applied to the work or that proper credit has been received for them in the contractor's statements.

The method for keeping cost records should be such that these records can be readily checked against data, kept by the contractor for his own use. This checking from the contractor's records should be done with as little inconvenience to him or his force as possible, and he should understand clearly at the outset just what data are to be obtained from him.

Records will be in a convenient and useful form if separated into two main groups, viz.: (I) Labor and (II) Supplies (including materials and tools). Each group should be arranged so that it can be used either for checking contractor's statements or for computing unit costs. Statements are generally composed of (a) pay-rolls, (b) charges or credits for material and tools, and (c) miscellaneous minor items such as insurance, telephone, etc. Material and tools are either delivered to the job as a debit to the owner or shipped away as a credit to him. For convenience in keeping records, the subdivisions of the work, for which unit costs are to be figured, should be clearly defined and a system of notation adopted for them at the outset.

Labor Records.—Records of the labor costs should cover the following items: (1) The total number of men at work each day. (2) The men's occupation, such as labor foreman, brick mason, carpenter, laborer, etc. (3) The particular subdivision of the work on which the men were employed, such as building forms, mixing concrete, laying pipe, etc. (4) The total hours spent on each subdivision of the work by each man or group of men. (5) The rate of pay which the workmen received. There should also be space in the records for figuring the labor cost of the several subdivisions of the work and an additional space for remarks. All items should be recorded in such form that they may be used either in checking up the contractor's statements or in figuring unit costs of the work. A form which on jobs amounting to about $150,000 has proved very convenient for keeping these data is shown in Fig. 1. This form may be printed either on cards or slips, which can eventually be filed for permanent record. One or several of these may be required daily, depending on the size of the job.

It is quite probable that somewhat similar methods of record keeping could be used for projects much larger than the one above mentioned.

Record of Supplies (Including Material and Tools).—Records of supplies should include (1) The amount delivered to or transferred from the job, (2) The subdivision of the work on which they were used (in the case of tools this will sometimes be quite indeterminable), (3) The unit and total cost of the above or in the case of credits, the amount which the contractor agrees to allow the owner for them, (4) The con-

RECORD OF LABOR

Day .... Date ....

MEN		WORK DISTRIBUTION	Total Hours Chargeable	Rate Per Hour	Total Hours X Rate	REMARKS
Number	Classification					

Fig. 1—Form for Labor Record.

RECORD OF SUPPLIES (Including Material and Tools) DEBIT

Day.................................... Date ....

ITEM	Amount	Unit	WORK DISTRIBUTION	COST		Contractor's Record Number	Date of Statement	REMARKS
				Unit	Total			

Fig. 2—Form for Debit Record of Supplies.

RECORD OF SUPPLIES (Including Material and Tools)—CREDIT

Day... Date ....

Item	Amount	Unit	Work Distribution	Agreed Credit		Contractor's Record Number	Date of Statement	Remarks
				Unit	Total			

Fig. 3—Form for Credit Record of Supplies.

tractor's record number of the invoice and (5) The date of the contractor's statement on which the items appeared. Two sets of record forms should be used, one for debits and one for credits, as shown in Figs. 2 and 3.

The record of unit prices paid as shown on the debit forms will be very helpful in determining the proper credit to be received for supplies transferred or sold from the job at its completion.

Before the contractor's final statement is passed for payment, a thorough comparison of the debit and credit records should be made in order to make certain that proper credit has been received for all supplies charged to the job and not used thereon.

9 Mile Subway System in Madrid, Spain

There is nearing completion in the city of Madrid, Spain, a modern rapid transit subway system of about 9 miles in length. This tunnel, as described in the Electric Railway Journal, is double track throughout and is of solid concrete construction similar to that of the Paris subway, but with dimensions slightly smaller.

The capital of Spain has developed rapidly, due to the increase in transportation facilities already provided. This has caused a spreading out of the population, as the inhabitants, trusting the transportation facilities as to future adequacy, have moved away from the centers. The network of electrical carlines is, however, inadequate to satisfy the growing needs of the capital.

Many of the city streets are so narrow as to preclude the use of more than a single track. The consequent throttling of traffic, added to the tie-up caused by congestion of vehicles, leads to a service necessarily very slow and irregular. This condition cannot be remedied by increasing the speed of the vehicles and adding to the number of cars, as the difficulties at the crossings would make matters worse rather than better.

On the "Metropolitano" the average speed will be 15.5 miles per hour, with sufficient capacity to permit a 2 to 3 minute headway between trains. These will consist of 5 car trains, comfortably accommodating 250 persons per train. The 2-track tunnel has been designed to accommodate wide and comfortable cars, which will be well lighted.

Material such as rails, ties, car bodies for the motor cars and trailers, trusses for the shops, machinery, etc., are being produced in Spain. The motors, forward trucks and various operating accessories are being furnished by well-known American manufacturers.

The Need for Complete and Accurate Cost Data

By P. W. PINKERTON.
Senior Accountant, Geo. B. Buist Co., Indianapolis, Ind.

Too many of the engineering cost figures which have been published lack the element of permanent value to such an extent as to make them only temporarily interesting. It is of no value to the man who desires to bid on plowing and barrow work in Colorado, to have only the following data of a job he or someone else did 10 years ago in Louisiana:

Item.	Cost per cu. yd.
Plowing	$0.01½
Loading	.10
Wheeling and dumping	.05
Spreading and finishing	.00½
Foreman	.00¾
Water-boy	.00¼
Attending run planks	.00½
	$0.18½

Or even if he knows the rate of pay per day for each of these classes of men, he still has insufficient data, unless he knows the number of hours worked per day.

It may be argued that, of course, all this will be on the records. True, it should be, and usually is in factory data, but the general contractor, who will undertake anything from erecting a telephone line to building an emergency fleet vessel—and has shown that he can do both successfully—has too many records of too many units, some of which he may have no occasion to refer to for years, to justify him in paying rent on a place to store more than a summary in the most readily usable form. If to the above record, then, is added the rates of pay and number of hours worked, the data will be complete, but still not in the best form, because each time the contractor wants to use the figures he has to divide through to find the number of units per man per hour.

But suppose him to have the data in the following form:

Plowing and Barrow Work.
Average earth Runways nearly level.
Haul 85 ft. Hourly output of following gang, 33 cu. yds.:

Item	Number of men.
Plow team and driver	1
Plow shaker	1
Loaders	22
Barrow men	11
Spreading and finishing	1
Foreman	1
Water-boy	1
Attending run planks	1

Then when he wants to bid on his Colorado job, he will learn what he will have to pay for labor and can make the following estimate:

Plow team and driver, 1@80c per hr	$ 0.80
Plow shaker, 1@40c per hr	.40
Foreman, 1@75c per hr	.75
Water-boy, 1@25c per hr	.25
Others, 35@35c per hr	12.25
Labor cost per hour	$14.45

With an output of 33 cu. yd. per hours the cost will be $0.438 per cu. yd., which is a very different figure from his cost in Louisiana before the war.

At the same time we must, of course, recognize that the output may not be the same. There is where the contractor's experience can not be replaced by figures, but if he determines that the conditions are such that his output will be only 25 cu. yd. per hour, he still has the data showing the economical organization of gang for a proper correlation of the work.

A simple example has been given, but in much contracting work this becomes an important factor in the condensation of records and their utility for future use. In steam shovel work, for example, it is best to make the permanent record one of quantities instead of values: coal burned in pounds per yard of material excavated instead of in cents per yard; repairs in number of each per million yards; lubricants in gallons of each per million yards, etc., in order that no matter what the cost of each delivered at some other place and time may be, the cost per yard may be ascertained.

But it is not to be supposed that this is a method to be used instead of the common method of cents per unit of quantity. It is an addition to that. The dual purpose of cost accounting has been well defined by Gillette as:

"1. To enable a manager to analyze unit costs with a view to securing the minimum cost possible of attainment under existing conditions.

"2. To provide data upon which to base estimates of the probable cost of projected work."

To accomplish the first aim the ordinary method of cents per unit is a very valuable adjunct in seeing that the cost stays below the contract price, but for comparison with jobs done previously under different conditions, it is of no value. If one is to know whether as much is being accomplished as should be, he must have his data in terms of men-hours, horse-hours, and machine-hours per unit, and in no other way can he know whether his organization is working efficiently.

In factory management the burden to be divided among the units of work accomplished is a factor which should undergo, under normal conditions, changes only gradual, never large and sudden, and never very different in different classes of work. But the burden in contracting work varies greatly with each job undertaken. Suppose it costs a contractor $60,000 to place his equipment on the site of the work. If the job contains, then, 60,000 units of work, the burden for this one item will be $1.00 per unit, but if there are six million units of work to be done, the burden for this item is only 1 ct. per unit.

This constant change of location makes necessary a rigid analysis of many more items than are usually kept track of. All of the burden items have to be analyzed for future estimates. It is not sufficient to say that the cost of establishing camp is $4,000, or a certain number of cents per unit of work to be done, and charge that off as the units are accomplished. The cost of establishing camp must itself be analyzed: getting materials together, loading, hauling, transferring, to freight cars, unloading from cars, hauling again, unloading from wagons, setting up. These costs should be recorded in various units, such as per pound of weight, per ton-mile hauled, per man to be housed in camp, etc., and in all cases should be finally recorded in terms of cost by hours of men and team labor, as well as in terms of cost by dollars and cents, so as to be of value for future estimates of cost under changed conditions.

Until our engineering cost data are published in terms of labor-hours and material-tons, gallons, etc., per unit of work accomplished, they are going to be of only passing interest instead of being permanently valuable. The reason that cost systems are meeting with such continued opposition among contractors is undoubtedly to be found in this very failure to carry the data far enough. The failure is the more strange when it is safe to say that not one more man's time or one more printed form would be required to make the data complete.

The reports of Dun and Bradstreet show an abnormal number of failures in the contracting business, a fact which seems to prove that the contractor needs cost data as much as any other business man, especially since the conditions under which he works are changing so rapidly that without thoroughly accurate data his bids are likely to be only estimates. His plant is constantly being shifted; the weather conditions under which the work is done are a vital factor; materials entering into the work vary daily in suitability and adaptability, or in the case of excavation are ever-changing in the degree of difficulty of handling; there is always more or less shitting of the occupations of the different men; and the percentage of unskilled labor to the whole is greater. The further fact that the contractor's work is done now in one city, now in another, perhaps even now in one country, now in another, adds to the need for the recording of accurate and complete data.

Progress of Federal Railway Valuation Work.—According to a recent statement of Director C. A. Prouty before the Appropriations Committee of the House of Representatives, the federal valution department had expended $13,706,000 up to the end of Dec. 31, 1918, of which $13,207,000 had been spent on railway valuation. The average force of the division of valuation during 1918 was 1,325 men. Mr. Prouty stated that the road and track parties will substantially complete their work this year in all districts. Four parties have already been disbanded in the Pacific district and five in the Southern district. The land and the field acconnting work will be completed in about two years, while the office work will be completed in about three years. It is estimated that the division will receive completed reports from the engineering section on 50,000 miles of road during 1919, similar reports having been received on 25,000 miles of road up to Jan. 1 of this year.

Bonus Plans for Motor Truck Operators

Examples of various types of bonus plans that have proved successful in securing more efficient motor truck operation are given by Mr. Harold P. Gould, chairman Truck Owners' Conference, Inc., Chicago, in a recent issue of 100% Magazine. The matter following is reprinted from the article.

The Economy Bonus.—The summary of the Economy Bonus Plans includes plans for the following purposes:

(a) Lowering Per Mile Cost.
(b) Increasing Tire Mileage.
(c) Decreasing Spring Breakage.
(d) Decreasing Accidents.
(e) Increasing Gasoline Mileage.
(f) Good Behavior.
(g) Regular Attendance.
(h) Not Getting Stuck on the Road.
(i) Keeping Car Out of Repair Shop.
(j) Reducing Customer Complaints.

Lowering Per Mile Costs.—Ward & Ward, Inc., of Buffalo, have worked out a very successful bonus plan based on the cost of operation per mile. With the allowed cost at 7 ct. a mile, they give the driver all the saving he can effect on this standard and deduct from his bonus the cost of all accidents unless proved to be outside his control.

Production remains at a predetermined standard because the deliveries are made to customers on fixed routes, under very nearly standard conditions of roads and loads; time does not enter in, because if the driver takes longer than he should he is simply running his day longer without cost to the company. The deduction for accidents has been carefully made under Mr. Ward's personal supervision.

First of all, a fair wage is paid; the man starts at $20 a week, the next month receives $22 a week and the sixth month $24.

In figuring cost per mile on 1½-ton trucks, garage cost, depreciation and insurance were not included and it came to gas, oil and tires.

Bonus payments are made every four months. Three drivers earned at the last distribution $75, $50 and $30, respectively; three times that sum for 12 months is a very respectable bonus earning.

Better satisfied drivers, more careful with their trucks, and working for the interest of the company, as well as lower maintenance cost on the cars were the good results of the use of this bonus plan. Three cars were run nearly 1,000 miles a month for 11 months each and were laid up only a total of five days for repairs.

Four Combined Bonuses.—The Gilman Trucking Co. of Cleveland offers its drivers four simple bonus payments of $5 each for accomplishing four different results, as follows:

1. For regular attendance and no absence without excuse previously granted by the foreman.
2. For good behavior.
3. For not getting stuck on the road.
4. For keeping the truck out of the shop in working hours.

This made it possible for each driver to earn $20 per month for exercising proper care, and resulted in lower cost and greater production to the company.

Spring and Tire Bonus.—McCrady Brothers, in the coal and building material business in Pittsburgh, are operating two simple bonus plans with excellent results, the first on tires and the second on springs.

Each driver is offered $1 for each 1000 miles he runs his truck over the maker's guaranteed 7,000, and $2 for each 1,000 miles he runs his duals, or large single tires on the rear wheels, over the maker's guarantee.

When a driver runs his tires 14,000 miles, for instance, he earns $7 bonus on each front wheel and $14 for each rear wheel, a total of $42 bonus.

As it costs the company from $12 to $22 per 1,000 miles for one of these tires, for the first 7,000 miles, the extra dollar or two paid in bonus is earning from 10 to 12 times its cost to the company.

The good results are not only satisfied drivers and increased mileage on tires, for when the rear tires are so handled as to run more miles, it stands to reason that the differential will run more miles and the engine will run further without an overhaul. Careful driving means longer wear on every part of the machine.

A 10 per cent overload is all that is allowed on these trucks and the drivers have no desire to put on more load or to speed the trucks because it is working to their detriment in the tire bonus.

One driver that earned a bonus for running his front tires 7,000 miles over the guaranteed distance, hauled 770 tons more in a three months' contest than another driver with a lower tire mileage in the same time, proving that the economy bonus on tires did not lessen the production of the truck.

When William McCrady offered his drivers a $3 bonus for every month in which no springs were broken, he did it to meet a serious situation, for on one truck they were averaging two broken springs a month at a cost of $20 each, or $40. Immediately after this bonus was offered the worst truck in the fleet ran two months without a broken spring

Again, there was reflected a benefit to the rest of the truck, because the breaking of the spring means the breaking of other parts at the same time. The more careful driving to earn the spring bonus pays hundreds of dollars each year on a machine in lessened repair bills on other parts of the truck.

Joseph Horne Co. of Pittsburgh, whose department store fleet has received effective administrative attention from Mr. F. C. Schatz, has developed several effective economy bonus plans.

The first bonus is an efficiency bonus, figured by crediting for good conduct and good mileage and debiting the driver for failures and complaints registered by customers with the complaint department.

The second bonus is given for the care of the car. No repairs are made without the authorization of Defect Cards, initialed by the drivers, so that this item as affecting their earnings can be kept in the control of the driver to a certain extent.

The third bonus is for economy in tire cost, or, in other words, for high tire mileage.

The fourth bonus is the half-yearly no-accident bonus. The driver forfeits his whole bonus if he has an accident within the six months' period, with one exception; he is not responsible if his car, left standing empty at the curb, is hit by another vehicle.

These four bonus plans in conjunction have been very successful in rewarding the better operators, causing the poorer men to strive for better records and the consequent better earning.

Wilson & Co. of Chicago have recently inaugurated a plan of giving prizes for tire economy. They give the driver 30 per cent of the "gravy" on sets of tires or single tires for number of miles run over 10,000, guarding against damage to the rims by the regulation that tires must be changed when worn down to within ¾ in. of the steel base

Pooled No-Accident Bonus.—Tiffany Studios of New York have a simple pooled no-accident bonus for the drivers and helpers on their trucks. They feel that alertness and watchfulness on the part of the helpers will tend in great measure to prevent accidents, so they are allowed the same bonus as the drivers.

Each man is allowed a bonus at the rate of $10 a month, payable twice a year, or $60 every six months.

It is understood that if an accident occurs through carelessness on the part of any of the drivers or helpers, its cost will be deducted from the bonus fund, so that all of the drivers and helpers will be affected. This makes all of them take an interest in preventing accidents, not only to themselves, but to each other.

The company carries insurance protecting it against damage to other cars, but they have so few accidents that they have dropped the insurance covering their own trucks and by carrying it themselves, are ahead on the deal.

They have had so few accidents which their insurance has not adequately covered that they have not as yet made any deductions from the bonus account, so that the men have always received their $10 per month in full.

If any man leaves their employ he forfeits his interest in the unpaid bonus fund, and it is distributed among the remaining men. This helps to keep the men satisfied with their positions and to hold them on the job.

The Miller North Broad Storage Co. of Philadelphia operated a similar no-accident bonus plan for three months during the dullest part of their season.

This was an unfortunate time to test it out, by reason of the fact that they were unable at all times to make up the expenses incurred through accidents as promptly as they should have done in a busier season, and it tended to throw discredit upon the bonus.

At the end of three months, when they expected to get the greatest benefit from the plan, conditions compelled them to make a substantial raise in the wage of the men, and because of certain weaknesses in the bonus plan, they felt it prudent at the time to abandon it.

Paper Credit Bonus.—Parke, Davis & Co. of Detroit have a simple economy bonus in use for the drivers of their eight city delivery trucks. Each month that a driver has no accident, whether his own or another driver's fault—and the loss of the smallest piece of equipment is put in the category of accidents—he receives a $5 paper credit bonus, payable in cash on the first of May each year.

For the least or the greatest accident in a month a driver forfeits his entire $5 credit. A nightly inspection of the cars at their garage carefully checks up the condition of the machines and their equipment.

The excellent effect of this plan may be seen from a study of the May, 1919, distribution: Four drivers received the full amount of $60, one man received $50, and three $55. One driver with one accident charged against him delivers in the thick of traffic all the year round.

This is the more remarkable when the comprehensiveness of the conditions covered by the bonus is remembered. The four perfect records mean that four cars had suffered no damage whatever from accident, and that they had lost not so much as wrench during the year's service.

The Jacob Van Skiver Co. of Philadelphia have a bonus, or demerit system, for reducing maintenance cost on their fleet of trucks. They pay their drivers $30 a week if they keep the trucks on the road, but if for any reason a truck is kept in the garage, the driver is penalized $1, or has his pay reduced from $5 to $4 per day until his truck is out again. He may be sent out on another truck if he is not needed to repair his own truck, but must stand the cut in salary just the same.

Whereas the drivers in the past often found something the matter with their cars in bad weather to keep them in the garage, they changed their minds and decided that they would rather drive outside than pay a dollar for the privilege of staying it.

The Credit System for Economy.—The Chicago Motor Bus Co. uses its debit and credit system as a pooled bonus plan to increase gasoline mileage, in one month paying out $300 in increased salaries to secure a saving of $1,200 in gasoline, and in another case paying all the employes from a pooled monthly bonus for the reduction of accidents on a mileage basis.

The Service Bonus (B4).—Service bonuses can hardly be classified with production and economy, or combined bonus plans and credit systems, although they have a definite effect in reducing the labor turnover and in making drivers satisfied with their jobs.

John Wanamaker has a simple bonus plan of giving the drivers $50 for every year of continuous service, and helpers $35 for a year of continuous service, in addition to the regular profit-sharing and welfare provisions made for all the employes of the Wanamaker organization

Strawbridge & Clothier of Philadelphia, another large retail store, has a yearly bonus plan for drivers and helpers.

The Fair, Chicago, offers a two weeks' vacation with full pay after a full year's service, in addition to a Christmas bonus of $75 after one year's service, $40 after six months' service, and $25 after three months' service.

The Crane Co., as is well known, gives every employe a Christmas present of 10 per cent of his yearly wages, which, at the customary wage of truck drivers, would amount to approximately $150 a year.

This plan is criticized by many as being nothing more than a deferred salary payment, since the 10 per cent bonus is counted on by all the employes when considering whether or not they will leave the company for higher immediate salary somewhere else. It certainly has nothing to do with the productivity or the faithful performance of scheduled duties by the employes individually.

Yearly Bonus With Saving Feature.—The Walter J. Crowder Co. of Philadelphia has met its labor problem by a systematic campaign to co-operate with their drivers. They formed an employes' organization to promote good fellowship and interest in the company, and instituted a simple bonus plan.

Each of the drivers pays 50 ct. a month in dues and the company puts 50 ct. with it for a Christmas saving fund; then, just before Christmas, each man receives a check for $12 from the company.

Systematic Raise in Wages.—The Erie Service Co. of Buffalo finds that a scheduled raise in wages keeps the drivers satisfied and works out well for the company.

They start a driver out at $20 a week, at the end of each month give him a raise of $1 per week until in six months' time his wage is $26 a week. In addition they pay 40 ct. an hour for overtime. The assured increase each month tends to keep the drivers satisfied until they are getting the maximum; from then on they stick to keep up that maximum income.

Basis for Bonuses Must Vary with Conditions.—It is easy to vary the basis of the bonus plans to suit the conditions in any particular business. If a business, for instance, is delivering to a large number of customers on long routes, it would be foolish to try to pay a bonus on the ton-mile basis, because the ton-mileage in that case would be very difficult to obtain and not worth the trouble. Per package delivered and the tons delivered in the total trip, number of calls made, or some other such basis should be used in such a case.

The Pooled Bonus.—Pooled bonuses have been very successful in certain factories where they have been tried, because as high as 700 operatives in a single department or plant can be placed upon a pooled or combined bonus that rewards every employe in the group for production records or economies of that group.

During the war the Goodrich Tire & Rubber Co. had as high as 700 employes in the balloon department, sharing a pooled bonus on the following basis: Every piece of work produced was credited to the bonus account at a pre-determined piece rate price. The wages for the workers were deducted in total from this fund and the balance distributed among the workers, all 700 of them, in proportion to their wages.

There are many cases where truck operators cannot in fairness accept a certain bonus standard and reward for their different drivers without working injustice upon the men who have the harder route or the more expensive runs for low production. The heavy and expensive run may be the run of lower production also through the exigencies of the business.

In this case a pooled bonus is suggested that credits all the drivers in a pool with the earnings of the fleet as a whole over previous earnings or earnings agreed upon as standard and, after the wages are deducted, leaves a bonus fund to be divided among the men according to the wages earned. The men will see to it in this kind of an arrangement that no one of the men reduces the profits of the others in the group by his laziness or poor methods.

The pool method has been used successfully by the Chicago Motor Bus Co. under the credit system, both in the machine repair shop and in the gasoline economy bonus.

Similar results are shown by the Tiffany Studios in their no-accident bonus.

While not having all the advantages of a bonus set upon individual records and paid to the drivers in proportion to their merit as in the Timken plan, the pooled bonus has other advantages not possessed by the individual bonus, because of the close supervision of the poorer workers by the better workers, which the individual system does not so much inspire. It is very much easier in many cases to install the pooled bonus.

Objections to Production and Economy Bonuses.—Mr. H. H. Ball of the Molstedt Lumber & Coal Co., New Rochelle, N. Y., stated that his company put in a bonus plan some time ago based on the number of tons of coal that his driver could deliver.

Not having a proper check or allowance for extra damage to the equipment, he found that it was only a short time before he had to take the extra help he saved in the production end, and put them in the repair department. He thinks that the result was just simply human nature on the part of the drivers, who got paid to produce without being penalized for causing extra repairing.

Col. James Kilbourne

The death early last month of Col. James Kilbourne, president of the Kilbourne & Jacobs Mfg. Co., Columbus, O., is worthy of more than brief notice, for it marks the passing of a man who for 40 years has occupied a position of prominence in the construction field.

Colonel Kilbourne is best known as the founder and builder of one of the largest contractors' equipment manufacturing plants in the middle west, the market operations of which extend all over the world. He has been an important constructive influence in this field for many years, and in that, as well as in the field of national citizenship, his absence will be noted.

Colonel Kilbourne was graduated from Kenyon College with the successive degrees of A. B. and A. M., from Harvard with the degree of LL.B, later receiving the degree of LL.D., from Kenyon. When the Civil War broke out he was offered a commission by the Governor of Ohio, but with his characteristic democratic spirit, refused it, enlisted with the 84th Ohio Volunteer Infantry and won his way to a captaincy. He served on the staff of General Tuttle, commanding the Third Division, Fifteenth Army Corps, and General John McArthur, commanding the First Division, Sixteenth Army Corps, Army of the Tennessee. At the end of the war he was a captain with the 95th Ohio Volunteer Infantry, but for "gallant and meritorious services" he was brevetted major, lieutenant colonel and colonel.

He practiced law for a time and then founded the Kilbourne & Jacobs Mfg. Co., of which he was president and general manager. Through his large ability and his personal popularity he soon became one of the big public figures of Ohio. He was a director of the Columbus, Hocking Valley & Toledo Ry., of the Columbus & Cincinnati Midland Ry. Co., a director of the Hayden Clinton National Bank, of the New First National Bank of Columbus and of the Midland Mutual Life Insurance Co.

In 1892 and 1896 he was a delegate from his home district to the Democratic National Convention, and in 1900 as a delegate at large he was chairman of the Ohio delegation. In 1901 he was nominated, by acclamation, for Governor of Ohio. He was president of the Ohio Centennial Commission in 1903, member of the American Society of Political and Social Science of the National Geographic Society, the National Forestry Association, the Ohio Historical and Archaeological Society, formerly vice president of the Leslie F. Orren Educational Society and former president of the Old Northwest Genealogical and Historical Society. He was also a member of the Ohio Society of New York.

On Oct. 3, 1869, he was married to Anna B., daughter of Gen. George B. Wright. Their children are James Russell Kilbourne, vice president and general manager of the Kilbourne & Jacobs Mfg. Co., Lincoln, Kilbourne and Mrs. Robert H. Jeffrey, all of Columbus. Their second son, George B. Kilbourne died in 1906.

Colonel Kilbourne, in his relations with labor instinctively inspired personal affection as well as the esprit de corps which, in this later industrial generation is so earnestly striven for through organization methods. His life was one of brisk action in anticipation of the needs of all that portion of mankind with which he came in contact, and his life work shows the effectiveness of a man of clear prevision on both the social and economic problems of humanity.

Railway Technical Engineers Get Increase in Salary

R. H. Aishton, Regional Director U. S. Railroad Administration, has authorized a wage increase for the engineers in his region below the grades of chief draftsman and assistant engineer. It is understood that this new schedule is effective July 1 for those roads that had put into effect Supplement 7 to General Order 27. For roads that had not put this supplement into effect it is understood authority was issued for them to put it into effect. This means that the engineers who did not get the increase of $25 per month, authorized under Supplement 7, will be given it. That order went into effect Sept. 1, 1918, and therefore entitles engineers who did not receive the benefit of it to receive back pay of $25 per month to Sept. 1, 1918. The matter of increased salaries for railway technical engineers was presented to the Wage Board by the American Association of Engineers at the hearing of March 31-April 2. On June 13 the association was informed that the U. S. Railroad Administration had transferred consideration of the request from the Wage Board to the regional directors. Since that time the association has been treating the case independently in each region.

Personals

Capt. H. J. Bradshaw has been elected city manager of Stanford, Tex.

Col. E. S. Brown, U. S. Corps of Engineers, has been assigned to take charge of the Cincinnati district engineer's office. He succeeds Col. Lansing H. Beach, who has been detailed for special duty.

Philip Petri, formerly district engineer on the Baltimore & Ohio eastern lines, at Pittsburgh, has been appointed division engineer, with office at Cumberland, Md., succeeding W. T. Hughes, transferred.

Robert A. Caughey of Pennsylvania State College has been appointed as associate professor of civil engineering at Iowa State College. Capt. William E. Duckering of the U. E. Engineers has also been appointed to the engineering department of Iowa State College.

Lieut.-Col. Harley B. Ferguson has assumed charge of the river engineering work of the Pittsburgh district, succeeding Col. Horton W. Stickle, for two years in charge of the Pittsburgh department. Col. Stickle was on the retired list at the time war was declared and was recalled to active duty to take charge of the Pittsburgh district.

Col. Frederick Mears, general manager of the American railroad lines in France during the war, has been appointed by President Woodrow Wilson as chief engineer in charge of construction of the government railroad in Alaska. He will be chairman of the Alaskan Engineering Commission. William C. Edes has been named consulting engineer to the commission.

J. H. Minton, senior assistant engineer of the Pennsylvania Lines West, Pittsburgh, has resigned to engage in other [illegible]. The field work formerly handled by Mr. Minton has been placed in charge of T. M. Bole, assistant engineer, Pittsburgh, and the office details and plans and specifications in connection with new construction work, formerly handled by Mr. Minton has been taken over by L. U. Struble, assistant engineer at Pittsburgh.

Capt. Bruce Aldrich, who will take charge of the Toronto office of the Asphalt Association as district engineer of the Canadian district with headquarters at the office of the H. K. McCann Co., Ltd., Toronto, Ont., is a native of London, England. He came to Canada at an early age and began his education in the public schools of Ottawa, returning [illegible] to England to complete his studies. From England he came to the United States and after serving as a volunteer in the United States Army in the Spanish-American and Philippine wars he was appointed [illegible] to a position in the office of inspector of asphalts and cements, engineer department, District of Columbia, where he served in [illegible] capacities testing paving materials under Prof. A. [illegible] New York until February 1912. In March 1912 he went to Baltimore, Md., where he organized and equipped the [illegible] laboratory in which were tested all the materials [illegible] new paving [illegible] of asphalt he supervised the [illegible] of more than [illegible] square yards of sheet asphalt [illegible] on [illegible] occasions as many as [illegible] asphalt plants working at the same time. At the outbreak of hostilities between the United States and Germany Mr. Aldrich responded to the call of the President and served in France as captain of [illegible] for one year, returning to the United States and resuming his former duties in Baltimore June [illegible]. He resigns this office to become connected with the Asphalt Association of 15 Maiden Lane, New York. Capt. Aldrich will devote his attention to co-operation with officials and engineers in the several provinces with a view to bringing about the most constructive results possible in asphaltic highway work.

News Letter

St. Louis Items

P. J. Hannan Co., Boatman's Bank Bldg., St. Louis, Mo., was awarded contract for building 16 miles of the Fort Smith-Subiaco & Rock Island R. R. between Dardanelle and Stranton, Ark. They will sublet this in quantities to suit outfits.

E. Y. Southerland of St. Louis, Mo., is going to do the bridging on the new Fort Smith-Subiaco & Rock Island R. R.

J. W. McMurray and Dan Munroe of Kansas City passed through here on their way home from Little Rock, Ark., after bidding on the Arkansas river bridges. All bids were rejected on account of being too high.

A. D. Thompson, 1005 Jefferson Bldg., Peoria, Ill., can use a 15 to 20-team outfit on road work in northern Illinois.

Mulvill Bros., Alton, Ill., have some railroad grading suitable for an 8 or 10-team outfit to sublet.

L. J. Smith and Scott Mitchell of the L. J. Smith Construction Co., Kansas City, Mo., were with us one day last week. They have added some more equipment onto their steam shovel job on the White river branch of the Missouri Pacific R. R.

P. J. Hannan Co. were instructed to begin work on three viaducts on the Wabash R. R in Indiana and Ohio.

John Strubel, Alton, Ill., can use an 8 or 10-team outfit on road work.

J. J. Printy has moved a part of his outfit on state road work near Springfield, Ill. Also has some teams at work on the Columbus, O., levee.

George Gist of Oak Park, Ill., came in looking for some team outfits.

D. J. Griffith has sold his ranch and farm and is going back into the the contracting business. His friend McMurray says that Dave is getting his second wind.

The Kansas City Bridge Co., Kansas City, Mo., were awarded a nice concrete job by the Missouri Pacific R. R. in Kansas City.

The Missouri State Highway Department has organized six surveying parties of 10 men each to begin surveying the first of 6,000 miles of road to be improved in Missouri during the next three years.

Charles and John Mulvill of Alton, Ill., and Dr. E. McLaughlin of Knoxville, Ia., are in a syndicate that bought a large tract of land near Alton, Ill. They have not announced what they intend to do with the property, but it is understood that they will decide definitely in a few days, but the general impression is that they purchased this land for a new company to be located in the Alton industrial district.

J. J. Grier, the well known boarding contractor and manager of the eating houses on the Rock Island system, died suddenly in Milwaukee while on a motor tour through Wisconsin. Mr. Grier's body was shipped to Kansas City and funeral services held there. Mr. Grier was born in Oconomowoc, Wis., 63 years ago. He married Miss Mary McCarthy of Chilton, Wis. The couple moved to Booneville, Ia., and from there to Colorado Springs, Colo., where Mr. Grier engaged in the railroad contracting business. Twenty years ago he came to Kansas City, where he built up the John J. Grier organization, in charge of the commissary departments of the Rock Island and Burlington railways. He is survived by his wife of the home address, 3117 Broadway, two brothers, James Grier, Omaha, Neb., M. T. Grier, Phoenix, Ariz., and four sisters, Mrs. Celia Cliggett of this city; Mrs. Catherine McCue, Denver; Mrs. Mary Atwood, York, Neb., and Mrs. Anna Grier Murphy of Kansas City.

The finest highways in the state of Missouri are to be built in St. Louis County, traversing four roads, with an extent of 52.36 miles, at a total cost of $1,717,320, of which sum the Federal Government through the state, is expected to furnish $830,805, according to plans and estimates submitted to and approved by the St. Louis County Court. William C. Elbring, County Highway Engineer, submitted estimates and plans which will be turned over to Harry Griffith, State Division Engineer of Highways, who will take them to Jefferson City to be passed upon by the State Highway Commission. The roads over which the highways are to be constructed are the St. Charles, the Manchester, the Gravois and the Lemay Ferry. The portion of each road nearest the city will be constructed of better material than the portion toward the county line. While approval of the State Highway Commission must be obtained before September in order to procure government aid, the work is to be started in the spring.

Contractors when in want of labor or work for their outfits write Koenig Labor Agency, 612 Walnut St., St. Louis, Mo., or 503 Delaware St., Kansas City, Mo.

The Middle States Construction Co are starting work on their state highway in Illinois this week. Will have their latest improved machinery on this job.

R. E. Cotton of Stresenreuter-Cotton & Co., was here arranging for labor and supplies for their new state highway job at Effingham, Ill.

Ben Reynolds will be in charge of the P. J. Hanna Co.'s work on the Fort Smith-Subiaco & Rock Island R. R, and P. W. Hannan will be in charge of their new office that they opened in the First National Bank building at Dardanelle, Ark.

R. T. Amis is finishing his team work at Appleton City, Mo., and going to move his team outfit onto a new job in Oklahoma.

Cook & O'Brien of Kansas City are grading East Sixth street in Topeka, Kans.

Contracts for the construction and equipment of the General Motors Co plant at Natural Bridge road and Union boulevard were awarded on a "cost plus" plan. A total of $5,000,000 will be spent in construction it is expected. The general contract was awarded to the George A. Fuller Co. of Detroit. Plumbing and mechanical equipment will be installed by the Thomas J. Sheehan Co. of St. Louis. The plant is to be one of the largest automobile assembling factories in the United States and 10,000 more workers will be employed.

Mrs. Cooper & Son are busy with their outfit at Fairfield, Ia. Subbed this job from A. L. Cook of Ottawa, Kans.

Newt. Paisley, manager of Koenig's Labor Agency, Kansas City, reports labor returning from the harvest fields and more plentiful in Kansas City now than it has been for some time.

A. B. KOENIG.

Industrial Notes

The Chicago Pneumatic Tool Co. announces the appointment of J. L. Canby as district manager of sales at Chicago, succeeding Nelson B. Gatch, who has been transferred to New York as district manager of sales.

In order to meet the large and growing demand for Plymouth industrial locomotives, clay working machinery and other Plymouth products, the Fate-Root-Heath Co. of Plymouth, O., has been incorporated with a capital stock of $1,000,000 and has taken over the property and business of the J. D. Fate Co. and the Root-Heath Mfg. Co., the plants of the two companies adjoining.

The Sullivan Machinery Co. announces the appointment of R. S. Weiner as district manager at El Paso, Tex., succeeding Don M. Sutor. Mr. Sutor has been transferred to the company's St. Louis office as district manager for Missouri, eastern Texas, Oklahoma, Kansas, western Kentucky and western Tennessee. The company's office at El Paso remains at Room 511, Mills Bldg., as heretofore.

Bucyrus Co., South Milwaukee, Wis., has established an office at 105 East 7th St., Pittsburg, Kan., for the convenience of coal stripping contractors and coal mining companies in ordering repairs for steam and electric shovels operating in the Pittsburg district. A stock of repair parts will be kept on hand for this purpose. A. M. Nielsen will be in charge.

The Chicago Pneumatic Tool Co. plans moving its general offices from Chicago to New York and toward this end is erecting an office building at 6-8 East 44th St., New York City. The structure, which is being built by the Westinghouse-Church-Kerr Co., is of combination steel, brick and limestone and will comprise initially ten stories, all to be occupied by the company. The ground floor is to be an attractively designed permanent exhibition room and will contain an interesting display of the many "Chicago pneumatic" products, including "Boyer" pneumatic hammers, "Little Giant" pneumatic and electric tools, rock and coal drills, "Giant" oil and gas engines, air compressors, etc., some of which will be shown in operation. In conjunction a completely equipped service station will be maintained. The operation of the company's six American plants and 26 sales and service branches can be directed more economically from New York. There will be continued in Chicago a sales and service organization more extensive than formerly. The new building is to be ready for occupancy early in 1920, at which time the transfer will be effected.

New York Office Building of Chicago Pneumatic Tool Co.

Obituaries

J. B. Orman, a well known railroad contractor, died July 21 at his home in Pueblo, Colo., aged 69. He was born in Muscatine, Ia., and came to Denver in 1869. His first contract was for the construction of the old Kansas Pacific from Sheridan, Kans., to Denver. With his brothers he assisted in building the following railways: Kansas Pacific, Denver & Rio Grande, Canadian Pacific, Oregon Pacific, Colorado Midland, Denver, Northwestern & Pacific, the Colorado & Northwestern, Santa Fe & Northern and the Florence & Cripple Creek. Mr. Orman was also a builder of many of the state's irrigation projects. The Uncompaghre tunnel, near Montrose, was built by him and he also constructed the Bessemer irrigation project in Pitkin County. In 1900 he was elected Governor of Colorado.

Building and Structural Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging (c) Quarries and Pits
(b) Rivers and Canals (d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings (c) Harbor Structures
(b) Bridges (d) Miscellaneous Structures
(e) Properties of Materials

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The "Secret" of Andrew Carnegie's Success

Everyone listens when the lips of a successful man open to tell "the secret of his success." But, curiously enough, we are usually disappointed when we hear the "secret." Is it because there is really no secret path to fame and fortune? Or is it because the successful man rarely analyzes the causes of his remarkable progress?

A careful and rather extensive study of the methods of successful managers has convinced the editor that there is no single cause of success in any line of endeavor. Success is a resultant of many causes properly co-ordinated to produce the desired effect. Even a simple economic problem involves many factors, and its correct solution necessitates the combination of all the factors in such a way as to produce the maximum of annual profit or the minimum unit cost. The highly successful man is one who is capable of solving not merely one but many economic problems. Hence, to ask such a man what is "the secret of his success" is on a par with asking a great mathematician what secret method he employs in solving difficult mathematical problems. A mathematician would reply: "There is no secret. Study the science of mathematics long and thoroughly, and if you have mathematical talent you will be able to do what I do." But in the realm of business even successful business men have been accustomed to regard "success" as a phenomenon rather than as the correct solution of many economic problems. Hence when Carnegie was interviewed about "success" he replied: "The secret of my success has been my practice of dividing my business into departments, placing the best man I could find in charge of each department, and then judging him by results". Yet this is a practice that was old before Carnegie used it, and many men who have used it have made no striking success.

Had Isaac Newton been interviewed by a daily reporter after the publication of his immortal "Principia," in which the laws of gravitation were first mathematically expounded, can you imagine his replying: "The secret of my success in solving these problems is my correct use of algebraic equations." Such a "secret" would be no secret, unless he were addressing people who knew nothing of algebra, and even then it would be but a small part of the entire reason for his success. However, so long as many people had no conception of the value of algebra as a tool of reason, Isaac Newton might have been justified in laying stress upon its value; but certainly he would never have pointed to algebra, or even to calculus, as the secret of his success.

Why, then, do successful business men persist in doing what successful mathematicians never attempt to do, namely, giv-

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

ing a few simple rules for attaining success? To this there is but one plausible answer: Business has not been generally regarded as the application of science, and, in fact, it has been largely unscientific. But business has at last entered its scientific era. Rules of economic procedure are being codified. Details of practice are being reduced to writing and classified for ready use when needed. Methods are being quantitatively tested and compared. Vague opinions are giving way to exact data. In a word, business is becoming a science—the great science of industrial economics. And very soon no industrial leader will announce the "secret" of his success, unless he has discovered a new economic method. Rather he will say: "Young man, you ask the secret of my success. I have none. Every principle that I have applied is already in print, and nearly all the details of my practice are known to any one that cares to study the books and articles on industrial economics. The nearest approach to a secret that I have to impart is this: While others have been looking for 'secrets' and happy leaps of luck, I have been studying all that I have had time to read or hear on business economics."

In this connection it may be well to point out that engineers and college educated men in general commonly make the mistake of regarding a knowledge of "general principles" as being far more important than a knowledge of details of practice. This is one of the logical blunders that is retarding progress, for most engineers are prone to read carelessly, or skip entirely, any article that relates mainly to detailed desciption of methods and results secured. It is true that articles that describe only methods, without giving comparative results are defective; but even a bare method may be sufficiently suggestive to lead to a trial from which quantitative data may be derived for comparative purposes.

Illustrative of the value of a detail of practice, there recently came to the editor's attention the following incident. A centrifugal pump for irrigation had been installed in a deep well pit. The engine was started and it pumped water for a few minutes. Then it began to "lose its vacuum" until it ceased to draw any water. A graduate engineer of several years' experience was sent by the pump manufacturer to remedy the defect. He went over the pump carefully, lifted the pipe from the pit and "calked" a few leaks at the joints. Still the pump would not work. He then declared that the trouble was with the well and not with the pumping outfit. So the owners drilled another expensive well. But the same trouble occurred with it, in spite of the fact that the well was larger and appeared to be capable of yielding a great volume of water. The hydraulic engineer was appealed to again, but with the same negative resnults. Finally an "uneducated" plumber suggested that he could make the pump work. He capped certain connections, and tested the pipe line by filling it with compressed air from an automobile pump. Major leaks in the joints were quickly discovered, and minor leaks were found by squirting oil over the joints, the oil bubbles indicating leaking air. Finally all joints were heated with a blowpipe, and an ordinary candle was held against the hot metal. The melting candle plugged every leak, and thereafter the pump worked perfectly.

In this case who was the better educated man, the "uneducated" plumber or the "educated" hydraulic engineer? The former solved a problem that the latter had failed to solve. The former saved two wells. The latter would have made them worthless, and worse, for 320 acres of land would have been unproductive. The land is now worth $60,000, because the wells are productive.

We have described this case at some length, because it serves to illustrate the worth of a very small item of knowledge—an item that a common plumber knew and that a graduate engineer of several years' experience did not know. Professional success, as well as business success, is dependent not only upon a knowledge of general principles but of many details.

The successful general manager need not necessarily know a multitude of details—although he usually does know a great many—but he must know how to select men equipped with detail knowledge. Such a general manager was Carnegie. He got the best assistants to be found, and he not only judged them by results but paid them according to results. While he does not mention the latter fact in giving his "secret of success," the liberal reward that his business and professional assistants received accounts largely for his success. They improved the steel manufacturing industry at a phenomenal rate, until Carnegie had left every steel competitor in the world in the ruck of the race. His own fortune has gone back to the public. But, what is far more important, the price of steel is much lower than it would have been had he not taught the world how to make it at greatly reduced cost.

Which of These Nine Causes of High Prices Is Predominant?

In a discussion of the causes of high prices a contemporary recently said:

"Since the armistice, inflation in money values has increased in astonishing volume, and all indications point to no sudden diminishing. The cost of labor is one of the chief factors in this inflation. Its action has a direct tendency to delay the decline in prices, and to postpone the reaction from the present condition, and to reduce wages now in general would not only be unthinkable from the point of view of labor, but also it would not affect a decrease in inflated values. High wages alone do not make for high prices. Other factors besides supply of gold are:

(1) Tariffs and taxation.
(2) Higher cost of materials.
(3) Decreased production.
(4) Speculation.
(5) Increase in urban population.
(6) Profiteering.
(7) Increase in wages without corresponding increase in unit production.
(8) Monopolistic combinations.

"Inflation is due not only to an increase in banking credit. Demand for goods has its effect, but so have supply and the changing expense of production. If one would find the causes of the change in prices, let him investigate all the data about labor, wages, efficiency, costs of material, freights, skill in management, machinery, new processes, taxation, insurance, and all other items which enter into the expense of production of every commodity."

Fortunately no extensive investigation of all these nine factors is necessary. There is one fundamental factor, and one only, that has changed greatly during the last five years, namely, the supply of money and its equivalent—bank deposits. "Taxes" play but little part in average prices. "High cost of materials" and "increase in wages" are effects rather than causes of general price inflation.

"Decreased production" is certainly a factor of considerable, though not commanding, importance. "Speculation" has always been with us, but has operated less to raise prices than to indicate the probability of a rise. "Increase in urban population" has been no faster in recent than in past years; moreover, it is doubtful whether it has ever affected the general price level, save possibly to lower it. "Profiteering" is merely a new name for a century-old phenomenon, which is probably no worse now than ever. "Monopolistic combinations" is also not a "war baby"; it was a vigorous adult ten years ago.

Although there are many causes of a high price level, we are now mainly concerned only with those causes that are operating with much greater energy than they were operating five years ago. Overshadowing all other causes is the enormous increase in currency and the consequent increase in bank deposits.

Greater output per man-day should be aimed at in order to reduce unit costs, but this should be the goal regardless of the quantity of money and bank deposits. The issue is confused when it is urged that the best way to lower prices is to increase production. Moreover there is such a thing as "over production," as is evident when foodstuffs are allowed to rot in the field. Many people are now suffering from the high price level, because of an "over production" of money and bank deposits. European nations printed billions of paper money, to use at home, and sent their gold abroad, thus causing "over production" of currency throughout the world. America should either export a billion of gold in exchange for foreign securities, or increase bank reserves and thus decrease bank deposits until a return to the prewar price level is attained.

Are Engineers Too Modest?

The late Henry Gordon Scott, past president of the American Institute of Electrical Engineers, said in an address:

"Whilst the legitimate field of work of the engineer is extremely broad and almost unlimited, yet as a rule he has apparently decided to keep in the background and only come to the front when called. The result of this policy is that when the opportunity comes, the engineer is taken at his own valuation and passed over for others, who, whilst not suffering from modesty, are lacking in engineering education and experience, and therefore are forced to call in engineers (to act in a subordinate position) to supply the incumbent's deficiency in the qualifications necessary for the office.

"A good illustration of this policy is furnished in the appointments made on two state public service commissions, in which the ten offices are filled by gentlemen whose occupations had been as follows: six lawyers, two manufacturers, one political officeholder, and one engineer. These commissioners have control of all matters pertaining to public service corporations; and as their functions are of an inquisitorial and critical nature, it is quite evident that their lack of engineering knowledge must be a severe handicap, not only to them but much more so to the state that employs them, and lastly, but not least, to the company or corporation suffering from their well-meant but misdirected efforts.

"What is the cause of this anomalous situation? Is it entirely the fault of the executive who makes these appointments? Has not the whole body of engineers some share in the blame? We have seen that there is today an inherent tendency to specialization in engineering, and that by far the greater number of our members are becoming experts in one or two subjects only, and that comparatively few attempt to keep in touch with the more general aspects of engineering. This condition is caused not so much by lack of willingness as by lack of time and opportunity."

There are several vacancies today on state public service commissions and one on the Interstate Commerce Commission, but what are the engineering societies doing to secure appointments of engineers on those commissions? Mr. Scott has attributed the lack of engineering activity in such matters to modesty. Would it not be more correct to call it ignorance and inertia? The ignorance consists in not knowing that engineering services cannot be marketed satisfactorily without advertising and salesmanship. The inertia is seen wherever engineers who are not ignorant of the power of advertising and salesmanship fail to take an active part in politics.

Mr. Scott has defined "engineering as the art of organizing and directing men, and of controlling the forces and materials of nature for the benefit of the human race." While this definition is too broad to be exact, it serves to emphasize the fact that engineers should not confine themselves to study of "the forces and materials of nature."

Mr. John B. Fisken recently said:

"Early in 1917 the authorities of Purdue University published the results of an analysis of the activities of the alumni of the School of Electrical Engineering. They took the period of ten years ending June, 1915, during which period 705 students had graduated, and showed the number and percentage engaged in various lines of work, as follows:

	Pct.
Manufacturing	35.4
Operating railway	19.6
Telephone and telegraph	6.5
Public	2.2
Teaching	6.1
Non-electrical engineering	4.5
Non-engineering	8.2
Miscellaneous engineering	10.0
Unaccounted for	3.9
Deceased	3.2
Total	99.6

"Commenting upon these figures, Professor C. Francis Harding, head of the School of Electrical Engineering, said 'that during the last few years there has seemed to be a greater tendency for electrical engineers to enter situations of a more or less commercial nature with the utilities and other positions requiring a broader training than was the case ten years ago.'"

The same is undoubtedly true also in the civil engineering field, with this addition: Many civil engineers are securing positions that were formerly held by mere politicians. However, taken as a whole, they have barely begun to oust professional politicians from the thousands of positions that would be better administered by civil engineers. Much advertising and salesmanship will be necessary if engineers are to make satisfactory headway.

Economical Limits of Bridge Spans

In discussing the general principles of bridge design, in Western Engineering, Charles E. Fowler said:

There is no need when considering bridges with spans of the greatest possible economical length to compare the cost with a tunnel or tunnels of the same traffic capacity as a bridge; because it may be considered as axiomatic that the tunnel scheme would be more costly. There is therefore no need to discuss the disagreeable features of tunnel transit, the impossibility of ventilating a tunnel for auto traffic, and its lack of safety under certain conditions.

The approximate span-lengths that may be taken as the greatest economically possible, are for simple spans, from 700 to 800 ft.; for suspension bridges, 3,000 ft.; for cantilever spans, 2,000 ft.; for arches under usual conditions, 1,000 ft.; for continuous girders proper, 800 to 1,000 ft.; and for draw spans, 550 ft. A suspension bridge would in most cases be more economical than a cantilever structure where the span exceeds 1,700 ft.; a cantilever or a continuous bridge would usually prove to be cheaper than any fixed spans that could be termed a really long span; the arch would be formed more economical than a suspension bridge for many reasonably long spans, where there are rocky banks or walls for the skewbacks. The type to adopt for any given situation depends mainly upon local conditions.

The economical number of spans to be used for any given ordinary crossing may be determined by the various formulas proposed for the purpose, but it is usually just as easy to make an estimate of cost for several bridges with different lengths of spans with their respective piers, and certainly the results attained by this method are usually more satisfactory.

Durability of Untreated Piling Above Low Tide

In tidal waters the portions of piles above mean low tide, although completely immersed only part of the time, may be practically saturated all the time. Wood constantly saturated with water is not subject to decay, and this fact makes the height to which saturation extends above low tide a question of considerable interest to the designing engineer.

The opinion of a number of engineers and construction companies, expressed in response to inquiries by the Forest Products Laboratory at Madison, Wis., is that untreated piling in water not infested with marine wood-borers will remain sound indefinitely if cut off at half tide. This height ranges in various ports from 2.3 to 4.5 ft. above low water. At certain places on the Atlantic coast, piles cut off at the height of half tide are still sound after from 50 to 100 years of service.

Untreated piling is destroyed by marine borers more rapidly than by decay, and the information given would, of course, have no practical use where these organisms are active.

Proposed Legislation for Strengthening of Patent Office.—The Patents Committee of Engineering Council has collaborated with the similar committee of National Research Council in developing a scheme for the improvement of the method of dealing with patents in this country. The staff of the patent office is itself actively engaged in this effort. Out of the report prepared by the National Research Council, and approved and adopted by Engineering Council as the report also of its Patents Committee, remedial legislation has taken form. Three bills have been introduced, known as H. R. 5011, a bill to make the patent office independent of the Department of the Interior or any other department, and to simplify the procedure of the courts with reference to assessment of damages or profits for infringement of patents; H. R. 5012, a bill to establish a single Court of Patent Appeals; and H. R. 7010, a bill to increase the force and salaries in the patent office.

Rebuilding an Old Masonry Arch Bridge

A stone masonry arch bridge built in 1881 was recently strengthened by jacketing it entirely in reinforced concrete. The bridge, of limestone, consists of five semicircular arches, and spans a creek near Delhi, Ill., and carries a single track line of the Chicago & Alton R. R.

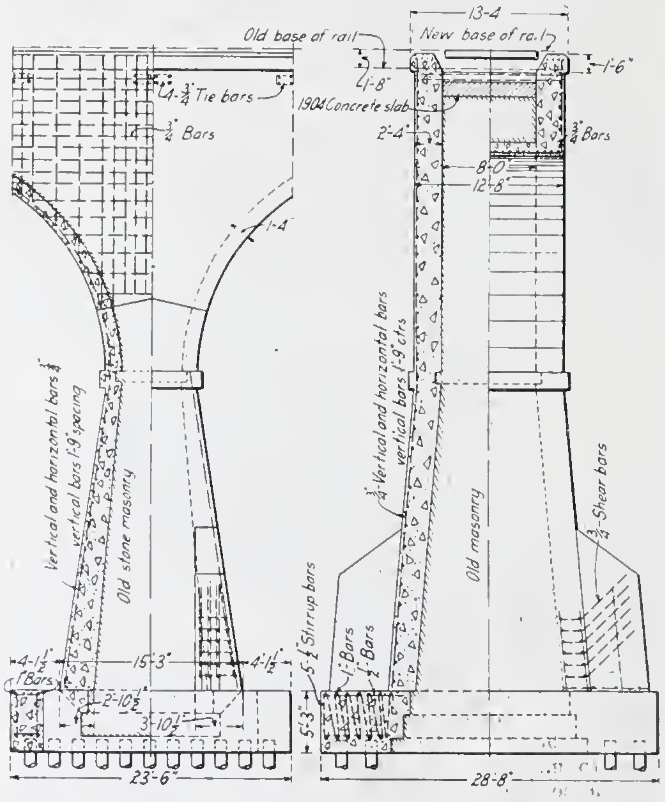
Originally the structure was but 8 ft. wide at the springing line of the arches, battering to 12 ft. 6 in at the tops of the footing. The piers were but 5 ft. wide, parallel to the track at the springing line. The spandrels over the arches and also over the abutments were solid masonry and originally carried the track on four lines of 8-in. x 16-in. stringers, supported on sills placed at intervals on the masonry. In 1901 the masonry showed considerable cracking, especially in the pier stones, and also spalling. The coping on which the track was supported also showed disintegration.

Section of Masonry Arch Bridge Built in 1881, Showing Concrete Jacketing in Progress.

In 1904 a new deck was placed on the structure. The upper layers of stone coping were secured and a plain concrete slab, in sections of 11 ft. 3 in. in length was placed on the old masonry. In 1911 lateral vibration and further disintegration and increased train loading necessitated a further repair and at this time the footings were widened in both directions, adtional piles being driven, and the piers were jacketed to a point some 5 ft. above the springing line. Lateral stiffness was increased by pairs of buttresses placed on each side of each pier.

In 1918, cracks had developed in the arches, some of which extended through the concrete floor slab placed in 1904. During that year the entire bridge was jacketed, the width of piers being increased so that now the top of the bridge has a width of 13 ft. 4 in. The copings were also carried above the slab floor of 1904, the latter being retained. The intrados of the arches were covered with a layer of concrete 1 ft. 4 in. thick. The whole was well reinforced with steel placed both vertically and circumferentially and near the outer face. Dowels of steel and stones removed from the old structure gave the necessary bond between the new and the old.

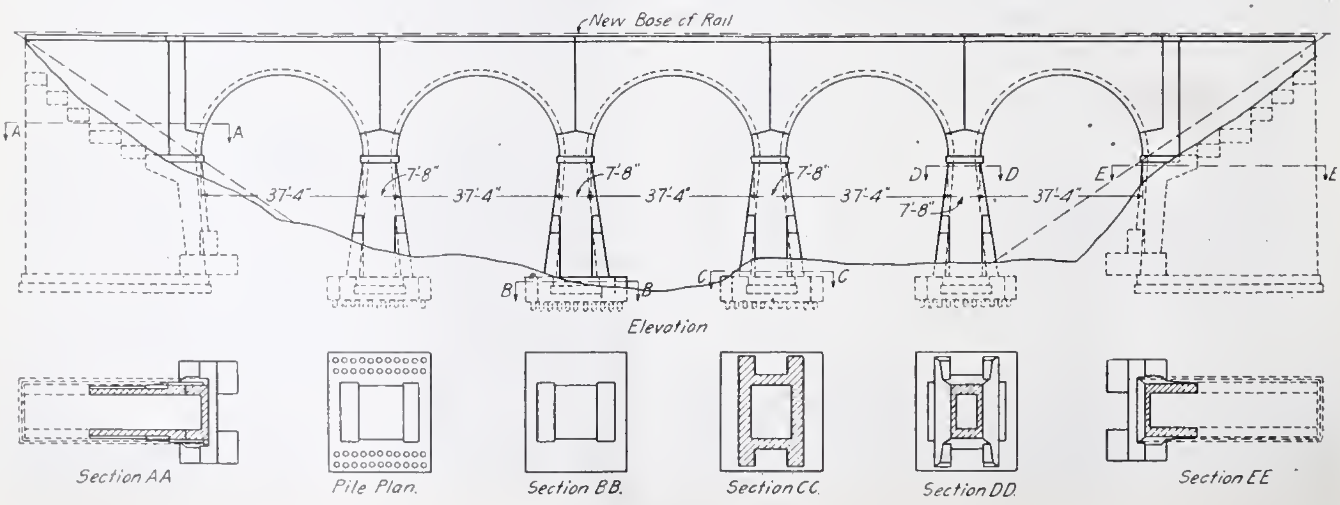
Concrete was mixed near the bridge and wheeled into place on a temporary plank deck placed on top of the bridge ties, and dumped directly into the forms. Concrete for the intrados was mixed rather dry and rammed into place from both sides, the original width of 8 ft. giving us particular difficulty in this work.



Details of Reinforcement.

The extension of the coping above the slab floor gave a pocket for a ballested track and in the reconstruction, the floor was coated with bitumen and ballast and ties placed in the usual way.

The latest reinforcement of this bridge has been conducted under the general direction of H. T. Douglas, Jr., chief engineer of the Chicago & Alton, and W. F. Rech, bridge engineer. J. E. Schwaab, resident engineer, supervised the work of the contractor, Stresenreuter, Cotton & Co., Chicago. The work is described in the Railway Maintenance Engineer, to which we are indebted for the matter in the article.



General Elevation of Bridge.

Why Engineers Were in Charge of War Time Emergency Building Construction

In England the greater part of the wartime emergency building construction was carried out by engineers. In an article in the July Journal of the American Institute of Architects, Robert Atkinson, headmaster of the School of the Architectural Association, London, ascribes the failure of architects to handle this work to their defective system of education which resulted in blindness and conservatism. Extracts from the article follow:

For a profession which for untold years had plowed its peaceful and only too well-worn furrow, to be suddenly transformed into a more or less useful branch of a conscriptive national machine under stress of war conditions, is a trial which only a homogeneous mass would be expected to survive—and with what result! The immediate requirement of great numbers of temporary buildings, hutting for camps, hospitals, depots, works, sheds, and the like, all to be erected in the quickest possible time from the stocks of materials available, presented problems in which organization and ingenuity in using the materials, or inventing new materials, played a much more important part than the designing or drawings which usually occupy the architect's time. The work needed to be executed in close touch with manufacturers or their engineers, in the fitting in of machinery, and needed also great knowledge of the working capabilities of materials so that economy might be carried to its greatest possible limit; in fact, the work approached almost as closely to the engineering as to the architectural side, not counting the great powers of organization necessary to avoid delay.

There arose at once a clamor for trained men of sufficient capacity and virility to jump into strange places and to tackle new problems as they developed, a chance, one would have thought, for the architect, yet with very few exceptions it was the engineer and not the architect who filled the breach. The architect proved to be hidebound to a degree, incapable of hustle, and lacking in fertility; the engineer, on the contrary, proved to be more practical, more energetic, more receptive, and a sufficiently good draughtsman for the occasion.

As a matter of fact, the life of the nation depended not a little upon its munition buildings and the housing of its workers. So enormous were the demands that existing buildings utterly failed to keep pace, and the architect, at first so indispensable, latterly so ignored, in failing to keep his place suffered the usual law of the elimination of the unfitted. What was the cause of such a debacle?

Now architects are just as patriotic as men in other sections of public life, and the rank and file were at the front before the need for their services was perceived at the rear; once lost in the maze of millions, their recall became difficult. Left—the middle-aged men and the crocks—it is cold comfort to think that had the vitality of the younger members been pitted against the young or old engineers, the result would have been different. (And, personally, I believe that the profession contains as much good material as any other.) As it is, a scapegoat must be found—the deficiency can, it is said, only have been the result of a defective system of education. The engineers, by their system of education, their scientific methods, their elimination of temperament and of sentiment, their constant experiments with new materials, with new methods, have kept alive the spark of evolution. Within their field they have constantly progressed, thus keeping the faculties of their students on the alert, with the result that they were found ready to undertake new methods with a fair chance of success. Well, then, let it be called the fault of the education of the architect, but, this being agreed, it would perhaps be as well to point out that it is not very logical to blame the education of the present for the defects of men educated 20, 30 or 40 years in the past, unless it be taken for granted that no changes in system have occurred during the intervening period, an assumption which I am afraid is very likely to occur, a defect in outlook which is consistent with the primary causes of the failure. What are the defects of our educational system? In the past they have been just those things which with cumulative effect have broken down under the strain of evolution, "blindness and conservatism."

Specific Gravity as a Measure of Strength of Wood

By the analysis of over 200,000 tests, the Forest Products Laboratory,* in co-operation with the University of Wisconsin has now definitely established the relation between the specific gravity of a wood and its strength property. The equations and tables derived can be used (1) for estimating the properties of any particular timber; (2) for selecting timber for any given purpose; (3) for comparing the various species, and (4) for determining in what way the species are exceptional and to what uses they are best adapted.

Only in compression parallel to the grain, the maximum crushing strength varies as directly as the specific gravity. No other relations can be expressed by an equation of the first degree.

Determination of Specific Gravity. Specific gravity of wood, as used in the bulletin, is based on the volume of the specimens when tested (green or air-dry) and their weight when in an oven-dry condition; that is, it is the ratio of the weight of the specimen of wood, oven-dry, to the weight of a volume of water equal to the volume of the specimen at the time of test. Because of the shrinkage which takes place in wood when it is dried, this figure is not the true specific gravity of a piece of oven-dry wood. The method, however, is easily applied to each specimen tested, and is the standard method of the Forest Service for the determination of a specific-gravity figure for use in studying the properties of wood.

Moisture Content of Test Specimens. Both green and air-dry specimens were used in the tests, and the relations between specific gravity and strength were determined separately for green and air-dry wood. Variations in the moisture content of wood have no effect on its mechanical properties so long as the wood is thoroughly green; they have considerable influence on these properties, however, as soon as the wood becomes air-dry, or partially air-dry. Accurate comparisons cannot be made between the properties of two lots of air-dry specimens unless they were tested at the same moisture content or adjustments made in the strength figures for difference in moisture content.

The moisture content of the air-dry material at the time of test varied from 8 to 18 per cent. Modulus of rupture and maximum strength in compression parallel to the grain were adjusted to a moisture content of 12 per cent before determinations of the relation of these properties to the specific gravity was made. This adjustment was possible because the laws governing the variation of these properties with varying moisture content are fairly well established. However, in the case of the other strength functions their variation with varying moisture content has not been studied in detail and no such adjustment is possible with any very great degree of accuracy. Consequently, the actual moisture content values as obtained from tests have been used in the determination of the relation of these properties to specific gravity.

Equations.—In deriving the equations, points showing the relation as specific gravity and strength function were platted on logarithmic paper and a single equation with powers of gravity that may be solved by arithmetical operations was established by trial, and not by the method of least squares. Obviously the amount of labor involved in the latter was out of question here. These are given under part I of table I.

In the second portion of the table, percentages of the equation values are given in groups for both green and air-dry wood. They are in a sense a measure of accuracy of the equations. For instance, under static bending of fiber stress at elastic limit, green wood, 10 per cent of all specimens had values of strength above 123 per cent of value as given by the equation $F = 10300 \sqrt[4]{G^5}$ 25 per cent of all specimens analyzed had values above 112 per cent of the figure given by the same equation and similar results for specimens whose strength was less than that given by the formula. Obviously 50 per cent of all specimens analyzed under the head and values between 91 and 112 per cent of values represented by the equation. Species and locality are the causes of the variations and the columns are so named.

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*Bulletin No. 676, United States Department of Agriculture, July 16, 1919. By J. A. Newlin, in Charge, Section of Timber Mechanics, and T. R. E. Wilson, Engineer Forest Products, "The Relation of the Shrinkage and Strength Properties of Wood to Its Specific Gravity."

In the third portion of the table the actual species and its location are enumerated and the various strength functions are given as percentages of values that would be determined by the equations themselves. Some 120 hardwoods and 60 conifers are represented in the table as given in Bulletin No. 676

Application of the Equation.—As an example of the use to which the table and diagrams may be put, suppose it is desired to obtain the strength in compression parallel to the grain of a piece of green hemlock (eastern) grown in the southern Appalachian region. Its specific gravity may be determined by any one of several means which may readily be devised, and we will say that it is found to be 0.38. In the table, the "species-locality" which is probably most nearly representative of the region in question is the eastern hemlock from Tennessee, and of this the maximum crushing strength is 29 per cent above the average for woods of the same specific gravity. To find what an average wood of a specific gravity of 0.38 will stand in compression parallel to the grain, we solve the equation $C = 6{,}900 \times 0.38$, which gives us a maximum crushing strength of about 2,600 lbs. per square inch. But since the compression strength of the Tennessee hemlock was 29 per cent high, it is reasonable to expect that the timber in question will also run about 29 per cent high, or that the value would be about 3,300 or 3,400 lbs. per square inch ($2{,}600 \times 1.29 = 3{,}354$). Any of the other properties of the hemlock under consideration may be estimated in a similar manner.

It must be borne in mind, however, that such equations can never take the place of tests of species whose properties are unknown. If any particular mechanical property is known, the specific gravity may be approximated and the other properties estimated; even the properties of woods upon which no test data are available can be estimated with a fair degree of accuracy from the results of specific gravity determinations. Nevertheless, it is apparent from a study of the table and diagrams that no one kind of test can replace a complete series of tests.

TABLE 1.—EQUATIONS AND VARIATIONS—SPECIFIC GRAVITY SHRINKAGE AND STRENGTH RELATIONS BASED ON TESTS OF SMALL CLEAR PIECES, GREEN AND AIR-DRY.

Species and locality.	Reference number.	Specific gravity, oven-dry, based on volume at time of test.	Moisture content.	Shrinkage from green to oven-dry condition.			—Static bending.—						Impact bending, 50-lb. hammer.				Compression parallel to grain.			Compression perpendicular to grain.	Hardness. Load required to embed a 0.444-inch ball one-half its diameter.			Shear.		Cleavage.		Tension.	
				In volume.	Radial.	Tangential.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Work to elastic limit.	Work to maximum load.	Total work.	Fiber stress at elastic limit.	Modulus of elasticity.	Work to elastic limit.	Height of drop causing complete failure.	Fiber stress at elastic limit.	Maximum crushing strength.	Modulus of elasticity.	fiber stress at elastic limit.	End surface.	Radial surface.	Tangential surface.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.
			Per cent.	Per cent of dimensions when green.			Lb. per sq.in	Lb. per sq.in.	1,000s of lbs per sq. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Lb. per sq.in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inches.	Lb. per sq.in.	Lb. per sq.in.	1,000s of lbs per sq. in.	Lb. per sq.in	Lbs.	Lbs.	Lbs.	Lb. per sq.in	Lb. per sq in.	Lbs.	Lbs.	Lb. per sq.in.	Lb. per sq.in.
I.—EQUATIONS FOR SHRINKAGE AND FOR EACH OF THE STRENGTH PROPERTIES OF GREEN AND AIR-DRY WOOD IN TERMS OF SPECIFIC GRAVITY.																													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Green							$F = 10300\sqrt[4]{G^5}$.	$M = 18500\sqrt[4]{G^5}$.	$E = 2500\,G^1$.	$W = 3.51\,G^2$.	$W = 42.7\,G^2$.	$W = 186.0\,G^2$.	$F = 23500\sqrt[4]{G^5}$.	$E = 3000\,G^1$.	$W = 15.1\,G^2$.	$H = 140\,G^2$.	$F = 6800\sqrt[4]{G^5}$.	$C = 6900\,G^1$.	$E = 2860\,G^1$.	$F = 2900\sqrt[4]{G^9}$.	$H = 3700\sqrt[4]{G^9}$.	$H = 3300\sqrt[4]{G^9}$.	$H = 3300\sqrt[4]{G^9}$.	$S = 2550\sqrt[3]{G^4}$.	$S = 2750\sqrt[3]{G^4}$.	$C = 1070\,G^2$.	$C = 1300\,G^2$.	$T = 1950\,G^2$.	$T = 2300\,G^2$.
Green to oven-dry				$S = 28\,G^1$.	$S = 9.5\,G^1$.	$S = 17.0\,G^1$.																							
Air-dry							$F = 19000\sqrt[4]{G^5}$.	$M = 26200\sqrt[4]{G^5}$.	$E = 3000\,G^1$.	$W = 9.0\,G^2$.	$W = 38.9\,G^2$.	$W = 118.0\,G^3$.	$F = 35000\sqrt[4]{G^5}$.	$E = 3550\,G^1$.	$W = 25\,G^2$.	$H = 111\,G^2$.	$F = 11000\sqrt[4]{G^5}$.	$C = 12000\,G^1$.	$E = 3500\,G^1$.	$F = 5200\sqrt[4]{G^9}$.	$H = 4800\sqrt[4]{G^9}$.	$H = 3600\sqrt[4]{G^9}$.	$H = 3800\sqrt[4]{G^9}$.	$S = 3630\sqrt[3]{G^4}$.	$S = 4000\sqrt[3]{G^4}$.	$C = 1100\,G^2$.	$C = 1200\,G^2$.	$T = 2100\,G^2$.	$T = 2400\,G^2$.
II.—MEASURE OF ACCURACY OF RESPECTIVE EQUATIONS																													
Proportion of species-locality.				Percentage of equation value.																									
10 per cent above, per cent				119	128	127	123	114	127	139	149	149	118	122	135	142	130	119	133	136	121	121	120	119	117	130	134	135	140
25 per cent above, per cent				110	116	109	112	108	113	117	123	123	110	109	121	118	115	111	117	115	110	111	111	109	109	118	116	118	127
25 per cent below, per cent				90	88	89	91	91	89	86	83	75	90	90	85	86	86	90	86	88	87	88	90	93	89	83	81	80	74
10 per cent below, per cent				80	77	79	79	84	76	72	70	60	84	80	71	76	73	83	72	77	70	78	81	89	83	68	58	55	57
10 per cent above, per cent				...	...	...	126	113	122	164	139	167	130	120	143	145	145	116	142	133	131	124	120	125	122	144	141	139	141
25 per cent above, per cent				...	...	...	111	106	110	135	117	130	112	110	125	120	127	108	120	118	115	111	112	112	110	126	121	127	122
25 per cent below, per cent				...	...	...	85	89	90	75	83	72	85	89	78	83	82	88	86	83	85	94	91	90	88	78	79	69	85
10 per cent below, per cent				...	...	...	75	80	81	60	66	58	73	81	63	70	68	81	67	74	79	83	83	79	78	56	64	54	52
III.—ACTUAL VALUE OF EACH PROPERTY FOR "SPECIES-LOCALITY" AS DETERMINED BY TESTS—EXPRESSED IN PERCENTAGE OF EQUATION VALUE.																													
[The original table in Bulletin No. 676 covers values for some 120 hardwoods and 60 conifers. Only the values for the more generally used woods are reprinted below.]																													
Basswood (Wisconsin):																													
Green	5	...	...	162	206	156	101	101	106	126	135	162	97	97	122	114	73	84	113	96	103	96	93	101	103	115	130	117	132
Air dry							113	90	157	108	64	91	62	108	51	55	75	93	185	117	108	123	115	150	158	159	194	108	144
Birch, paper (Wisconsin):																													
Green	73	...	...	116	147	109	70	78	84	59	151	146	82	82	77	137	62	68	71	61	56	77	76	78	78	87	83	92	66
Elm, cork (Wisc., Marathon County):																													
Green	126	...	...	...	...	...	83	101	85	77	137	111	101	79	128	101	...	94	...	83	89	93	94	99	101	76	87	...	...
Air dry							75	105	93	59	131	113	94	94	91	120	79	94	87	88	90	98	93	107	103	103	114	121	120
Gum, cotton (Louisiana):																													
Green	76	...	...	93	97	98	104	100	87	122	79	80	83	92	73	77	86	108	94	81	113	106	117	103	105	108	130	108	152
Air dry							76	80	84	76	53	58	74	83	73	61	80	99	85	79	114	106	103	98	109	130	112	82	122

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
Maple, silver (Wisconsin):																													
Green	56	...	...	96	72	97	83	87	85	88	132	107	82	80	92	110	81	82	86	100	112	112	112	116	124	132	132	[illegible]	[illegible]
Air dry	...	...	...	...	...	...	112	82	85	133	86	91	110	86	171	100	128	87	68	106	115	100	109	118	129	132	137	69	125
Oak, bur (Wisconsin):																													
Green	125	...	...	77	80	90	68	75	59	71	72	67	79	66	85	85	68	82	52	102	100	108	110	98	101	95	97	100	[illegible]
Air dry	...	...	...	...	...	...	62	63	54	71	56	45	71	66	79	56	58	76	59	79	72	94	91	80	95	45	72	48	8
Oak, red (Arkansas):																													
Green	119	...	...	91	78	86	77	89	88	63	91	101	93	92	87	94	76	88	82	107	110	111	114	101	94	102	107	106	11
Air dry	...	...	...	...	...	...	98	92	105	92	81	120	92	92	88	93	69	99	128	66	92	110	112	102	102	85	110	108	130
Oak, white (Indiana):																													
Green	138	...	...	86	85	88	88	89	88	93	87	76	87	87	77	87	88	85	76	77	93	100	100	91	100	83	106	88	[illegible]
Air dry	...	...	...	...	...	...	62	100	92	44	72	15	84	100	66	52	76	103	82	69	72	95	89	103	103	77	97	72	
Cedar, western red (Washington):																													
Green	10	...	...	93	80	101	140	124	124	190	121	110	133	121	180	121	160	135	135	149	159	104	108	128	119	112	92	100	[illegible]
Cedar, white (Wisconsin):																													
Green	1	...	...	85	75	95	115	106	87	196	156	132	105	90	161	128	97	98	90	151	110	88	88	126	115	156	128	119	121
Air dry	...	...	...	...	...	...	120	110	90	228	130	144	95	100	128	126	107	102	93	108	114	106	117	119	123	112	115	121	128
Cypress, bald (Louisiana):																													
Green	62	...	...	91	89	78	117	105	123	135	59	71	94	106	88	81	111	127	134	115	77	67	67	95	84	72	59	61	[illegible]
Air dry	...	...	...	...	...	...	111	115	120	135	88	144	75	85	74	88	135	138	131	78	91	84	88	76	57	50	56	41	[illegible]
Douglas fir (Chehalis County, Washington):																													
Green	46a	...	...	108	111	105	122	111	133	117	81	86	107	131	97	85	127	119	167	121	95	92	97	117	102	66	69	[illegible]	[illegible]
Hemlock, eastern (Tennessee):																													
Green	52	...	...	94	94	108	137	118	123	156	88	113	114	113	121	92	142	129	124	133	102	98	96	121	98	76	67	51	58
Air dry	...	...	...	...	...	...	123	101	110	151	78	116	125	114	154	149	163	115	115	119	95	83	80	85	86	30	48	...	24
Hemlock, eastern (Wisconsin):																													
Green	15	...	...	92	71	87	121	114	103	166	125	110	101	100	123	102	120	117	109	161	140	121	111	128	122	126	79	119	118
Air dry	...	...	...	...	...	...	101	97	97	142	98	156	84	85	110	92	115	115	105	121	146	103	86	118	118	88	67	83	...
Pine, loblolly (Florida):																													
Green	88	...	...	87	114	88	105	95	112	96	72	85	93	105	79	88	100	106	105	89	50	626	6	92	75	62	58	52	50
Air dry	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pine, lodgepole (Colorado):																													
Green	31	...	...	110	119	113	106	99	112	117	91	61	97	100	109	79	118	99	115	117	69	84	86	96	98	87	76	...	...
Air dry	...	...	...	...	...	...	129	109	113	188	121	105	69	88	66	86	113	108	101	130	86	95	112	95	80	98	72	...	...
Pine, longleaf (Florida):																													
Green	123	...	...	74	93	71	104	92	112	87	54	72	91	109	68	67	113	110	111	73	50	61	61	89	73	46	38	37	30
Air dry	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pine, longleaf (Lake Charles, La.):																													
Green	113	...	...	82	102	83	115	99	117	96	60	64	91	111	68	69	127	118	123	81	53	67	69	90	81	18	41	44	44
Air dry	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pine, longleaf (Tangipahoa Parish, La.):																													
Green	96	...	...	88	119	85	109	104	126	90	69	104	90	109	71	88	112	117	125	69	67	66	69	96	80	59	50	44	55
Air dry	...	...	...	...	...	...	105	107	117	94	95	96	94	110	85	96	111	121	109	92	66	73	80	113	89	77	15	61	52
Pine, longleaf (Mississippi):																													
Green	95	...	...	74	96	85	103	94	107	100	61	76	91	103	77	76	120	111	112	76	55	69	72	94	83	53	45	15	44
Air dry	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pine, Norway (Wisconsin):																													
Green	57	...	...	92	110	96	99	95	123	83	68	128	86	107	72	100	102	101	131	76	58	65	64	93	78	72	60	46	44
Air dry	...	...	...	...	...	...	119	117	123	128	106	110	106	115	106	96	128	126	129	77	76	81	90	98	76	81	67	77	95
Pine, western white (Montana):																													
Green	42	...	...	104	109	111	106	96	132	94	74	117	100	118	96	104	131	113	141	88	74	81	86	94	87	90	84	68	76
Air dry	...	...	...	...	...	...	126	106	136	144	149	146	119	138	121	139	150	111	153	110	77	96	88	...	51	55	53	...	34
Pine, white (Wisconsin):																													
Green	25	...	...	77	64	96	114	100	116	128	101	102	91	101	95	88	121	108	128	108	77	86	86	92	84	89	87	81	85
Air dry	...	...	...	...	...	...	122	108	122	156	110	172	85	106	85	104	117	115	117	131	109	115	108	92	101	128	97	92	97
Redwood (Albion, California):																													
Green	28	...	...	...	...	...	107	143	120	...	...	...	...	...	...	...	...	165	...	202	...	...	...	...	...	...	...	...	...
Air dry	...	...	...	...	...	...	86	101	96	...	...	...	...	...	...	...	143	114	92	118	...	...	...	79	73	...	...	...	...
Spruce, Engelmann (Grand County, Colo.):																													
Green	8	...	...	117	121	125	107	99	105	130	101	64	106	108	126	85	113	97	110	137	100	106	115	103	98	88	94	...	...
Air dry	...	...	...	...	...	...	97	117	100	121	107	114	92	103	110	116	122	116	101	132	91	83	90	109	104	121	98	...	...
Tamarack (Wisconsin):																													
Green	81	...	...	101	79	89	100	96	101	110	71	110	80	106	74	85	108	103	111	83	56	61	58	90	79	62	52	52	50
Air dry	...	...	...	...	...	...	97	97	106	94	64	90	86	92	88	81	103	110	113	85	60	72	69	93	85	81	67	79	63

Fully Equipped Industrial Town for Sale

The war department is offering for sale the town of Nitro, W. Va., a complete industrial community embracing 737 manufacturing buildings, housing accommodations for 20,000 persons, and the utilities and civic improvements that constitute the conveniences of a modern city. Nitro, built by the government at a cost of approximately $70,000,000, is the site of the second largest smokeless powder plant in the world. The bids, which must cover not only the powder plant and the other industrial units which were erected to prepare the ingredients essential to powder making, but the civic community as well, to which the United States also holds title, will be opened at noon on September 30, 1919, at the office of the chairman of the ordnance district salvage board, 1710 Market street, Philadelphia. The industrial community of Nitro stretches for more than four miles along the east bank of the Kanawha River. Here are to be found a sulphuric acid plant in seven units, the capacity of which is 700 tons per day of twenty-four hours; a nitric acid plant of four units, the capacity of which is 300 tons per day; a cotton purification plant of standard pulp mill design in four units, the capacity of which is 225 tons per day; a nitrating, colloiding and drying plant; sixteen shipping houses, or magazines, segregated for the storage of powder; thirty large storage buildings erected to handle the essential crude and raw material; a complete shop area, with fireproof machine shop fitted with modern tools, a carpenter shop, tin shop, paint shop and foundry; a box-making plant capable of turning out 4,000 metal-lined wooden containers a day; a 100-ton ice-making plant with insulated ice storage rooms; an absorption refrigerating plant consisting of five 160-ton units with brine-cooling equipment; two completely equipped general laboratories for chemical research routine plant analysis, and six special laboratories completely equipped for special plant determinations. Set upon the foothills, overlooking the industrial area with its bristling smokestacks, stands the civic community—more than 1,500 furnished portable houses, homes for the workmen who will make the manufacturing units producing institutions; seventy-five permanently constructed executive residences, hotels, boarding houses, dormitories, clubhouse, general and special stores, cafeterias, and moving picture houses, etc., etc., etc.

Gluing Wood Coated with Varnish or Shellac

Glue joints between wood surfaces which have been coated with shellac or varnish have low or very erratic strength. This has been thoroughly demonstrated by a recent test at the Forest Products Laboratory, Madison, Wis. Sixty pairs of test blocks were prepared in which one or both wood surfaces were varnished or shellacked and were joined with either casein or animal glue. A great many of these blocks fell apart before testing, and all which held together long enough to be tested sheared apart in the glue joint and not in the wood.

The highest strength value obtained was 1,712 lb. per square inch, which is low for casein glue. The other values were 1,000 lb. per square inch or less. It is evident, therefore, that all shellac or varnish should be carefully cleaned from wood which is to be glued, if high strength is desired. A few blocks were joined using shellac as a glue over surfaces previously coated with shellac. The maximum shear strength obtained was 1,425 lb., the minimum 450 lb., and the average 758 lb. per square inch. These values are low and do not indicate that shellac has gluing properties which compare favorably with casein or animal glue.

Senate Passes Bill for Relief of Building Contractors.—The U. S. Senate on Aug. 13 passed the bill providing for the relief of contractors who have been carrying on public building construction for the Treasury Department. The measure was passed by the House on July 31. The acting supervising architect estimates that the sums involved will approximate $2,000,000.

Establishing Standards in Construction*

By A. B. SEGUR,
Industrial Engineer, Chicago.

A few years ago we had occasion to make some very careful studies on certain types of building construction, to determine just how closely standards could be set on any particular contractor's work. To our surprise, we discovered on this class of work, that the difference between performing one job and another job was less than 1 per cent of the labor cost. This applies not simply to one foreman, but works out in the same way when applied to a number of different jobs or different contractors scattered over a large section of the country, and differs greatly as to the general character of the work. When the standards were applied to the erection of brick flat buildings on the North Side of Chicago, we found them to apply, when the various factors were taken into consideration, to work on depots in Oklahoma.

In fact, it seemed that when a foreman once struck his stride it made but little difference whether he was on one job or another job; the same characteristics of his ability to get the men to work seemed to hold. For instance, standards set on depots in Albuquerque, N. Mex., were found to hold on depots of a different design built in Oklahoma five years later by the same company, the same foreman, but with different men. Standards set on flat building construction on the North Side of Chicago held good on flat buildings on the Southwest Side of Chicago. In fact, it was possible to take off the quantities of labor with as great accuracy as it was possible to take off the quantities of materials estimated on a job, so long as one knew what the real standard of efficiency of the foreman on the job really was.

Desirability of Standards for the Contractor.—Perhaps one one of the things that the average contractor lacks, more than anything else, is a definite set of standards by which he can measure one gang against another, and by which he can measure his own output against the output of his competitors. Again, he lacks standard which he can apply to a job immediately and get a measure of performance on his work as soon as the job tickets come in, instead of waiting for a month or two until the conditions surrounding the job have been forgotten. Yet, the setting of standards on some classes of contracting work is no more difficult than setting standards on difficult manufacturing.

While the general contractors of the United States are thinking of possible co-operation in various lines, it might be well to make a study of the similarities and dissimilarities of the contracting business with other lines of business and determine how far the experience of people in other lines may be used in contracting. Let us consider first what the points of difference between construction work and manufacturing are.

Manufacturing work is generally carried on inside of a building of a definite area, while construction is generally carried on at widely separated points. At this point the essential differences seem to stop. Both parties have the same labor problems (although some people might disagree with this statement); both parties have the same problems in obtaining material, the same problems in transportation, similar problems in financing, similar problems in estimating. After all, when you study manufacturing as a whole, instead of studying a single shop, you will begin to find that the difference between a manufacturing job and a construction job is very small indeed.

The reason for the general thought that the problems are entirely different probably springs from the fact that, due to their general conditions, certain problems have been overstressed. The average contractor thinks of his work in terms of jobs as a unit rather than in terms of specific problems which apply to all jobs as a unit. Take, for instance, the labor problem. When considering the job as a unit, the labor problem does not loom up as a problem which allows of any definite solution. Other problems such as materials, deliveries, payments, and costs, seem of so much greater importance that the labor problem is left untouched. It is generally considered that the labor is floating labor, anyhow, and that, therefore, one has only the floating labor problem.

Applying Standard Principles to Wages.—Suppose that we consider the application of some standard principles to the labor problem. A strike is now on in Chicago, and the labor demand is $1 per hour. The union leaders, as I hear their side, do not claim that the labor is worth $1 per hour while the man is working, but the claim is that the brick mason, for example, works only five months out of the year and that he must make enough during those five months to keep him the entire year.

Suppose now, that the Associated General Contractors should consider this problem in its broad aspect. If contractors in different sections of the country were to work out their labor requirements on a curve, taking note of the amount of labor required of any particular type in any part of each period of the year, there is a possibility that the curve would be something like Fig. 1. This illustration, of course, is purely hypothetical, but it will be seen that the total requirements of these contractors for this particular type of labor are about constant throughout the year; that the only problem involved is one of shifting the maximum load from one section to the other. If, after a study, this should not prove to be feasible, the contractor might be able to work with manufacturers in the same district who were working in allied lines. I am very well acquainted with manufacturers, for instance, who make use of some skilled labor of contractors where the condition is something like the illustration in Fig. 2. The resulting curve of an actual condition does not follow, of course, as well as the resulting curve of a hypothetical condition; but, nevertheless, there is a considerable amount of equalization possible in conditions as they exist in Chicago at the present time. And yet, there are a large number of men from a construction gang, lying idle on the streets at the very time that the manufacturers are breaking in new men to handle their work, and vice versa.

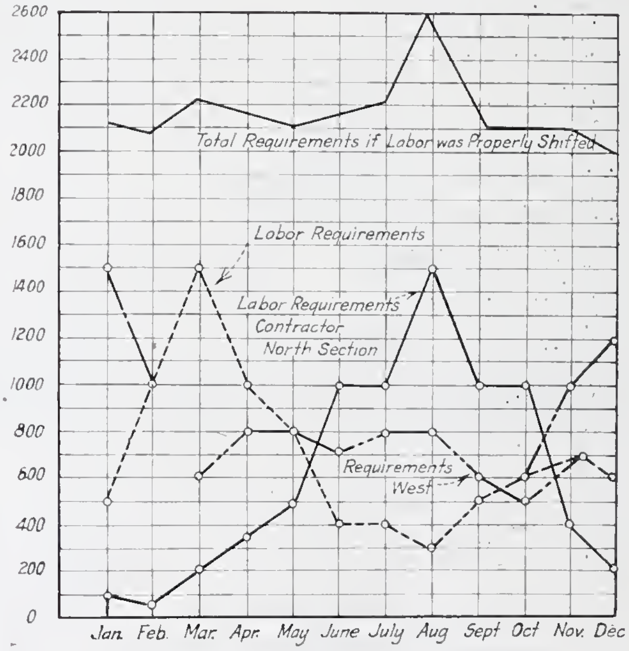

Fig. 1—Diagram Showing Possibility of Shifting Labor to Meet Demand.

Co-operation between the Contractors' Association and the Manufacturers' Association in this regard would be of great benefit to both; and its effect on the present demand for higher wages could be made a very real factor in determining a fair wage-scale.

A few years ago, a suggestion of this kind would have been laughed at, but, from what little experience I have had in recent years with general contractors, I am inclined to believe that there are possibilities of this kind at the present time.

Applying Standard Principles to Costs.—Another illustration is that of costs. The reason for the lack of standardized costs on construction jobs up to recent years, I think, may be traced back to the old idea that each new job in contracting was a gamble. It is only within recent years that the average contractor has considered that he is in business in the same way that the manufacturer is in business, and that it is just as much to his interest to make a moderate profit on every job by accurate study of costs, as to make a very large profit on one job and lose on the next one, due to guess-work estimating, depending upon sheer luck to carry him through the year with something as a bank balance. This condition also is being corrected today, and you will find in some big offices just as much care being taken in estimating on the basis of unit cost, as you will find in almost any manufacturing concern. This has led to a standard basis of prices, and there are a great many contractors who adhere to a one-price system of handling their jobs. The customer has no more chance to get prices cut on a particular piece of work than the customer who deals with the average manufacturer. Many contractors have been inclined to think that since their work was not surrounded by four walls, they are unable to obtain standard conditions on anything and were unable to translate good working conditions from one job to another. If you will look over the average job, however, you will discover that this is almost altogether a matter of planning on the job, and that with the proper plan, the difference between various jobs of a similar character is comparatively small after all.

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*From a report prepared for the Committee on Methods of the Associated General Contractors of America, and printed in the August News Letter of the Association.

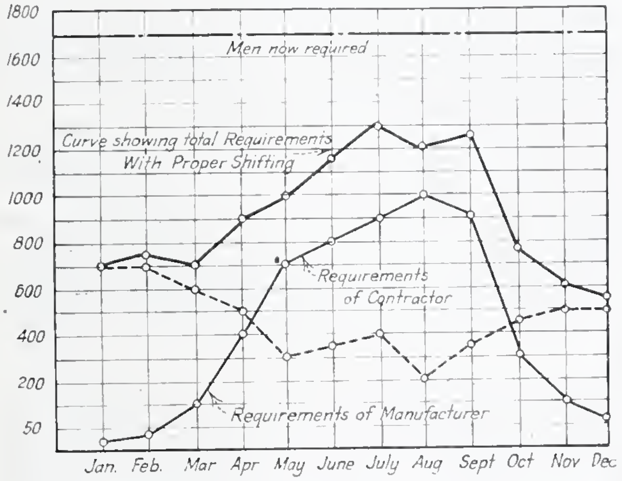

Fig. 2—Diagram Showing Possibility of Shifting Labor Between Local Industries.

Standardizing Brick Laying.—Suppose we take, for instance, a job of bricklaying. If we should divide this work into three divisions, and classify the various elements that enter into a job of brick laying, we would probably find the following:

Standard Conditions.	Conditions Which Can Be Standardized by Proper Planning and Data.	Conditions Which Can Never Be Standardized Completely.
Weight of mortar per brick. Weight of brick. Weight of unit load of brick. Weight of unit load of mortar. Pattern in which brick must be laid outside. Pattern in which brick must be laid inside. Condition of the inside of wall. Pattern of arches and other openings within certain definite limits. Style of laying up corners. Line. Pump.	Height of wall on which workmen must place his material by the use of proper scaffolding. Level at which material must be hauled by use of proper elevator equipment. Surrounding conditions such as carpenter work, plumbing, electric lighting, etc., by proper planning. Labor performed per unit of time by the use of proper standards. General working conditions inside of standard buildings by proper arrangement between contractors.	Conditions outside of building.

It will be noted that all the items which are generally considered more or less variable, that only one of the entire list need be a permanent variable, and even this, with proper treatment, may be reduced to more or less of a standard basis. In science, we find that generally, it is best to start with the known and proceed to the unknown, so we take the things that we are sure of and work toward the things which we are not certain of. I am inclined to believe that the reason that the average man on construction work believes that this work cannot be standardized, is that he is thinking continually of the variables and not sufficiently of the items which are applicable to standards.

Variables in Manufacturing.—The other man's problems always seem a great deal easier than our own. Most men are inclined to believe that every factory has constant conditions of manufacturing and that all the problems of the manufacturer have been solved by the factory a great many years ago. I sometimes wonder what the average contractor would say or think if he were to go with us through the many industries it has been our privilege to survey during the war. He would probably find that many of the manufacturing plants which he has been regarding with awe for a great many years, were no better off, in a great many ways, than himself. Many manufacturing plants can have no more definite policy as to output or as to sales policy by which to govern their manufacturing than the contractor. Take, for instance, the foundry, machine shop, or structural shop The following table would represent a fair comparison between two jobs in a machine shop which might very possibly come through in succession:

Name of Variable.	Piece No. 1.	Piece No. 2.
Weight	1 pound	5 tons
Limits of accuracy	.0001"	.1"
Number of pieces	5	2
Material	brass	cast iron
Brought from	neighboring shop	a distance
Shipped to	customer	second manufacturer
Machine shop equipment	on hand	to be erected
Skill required	medium	very high
Time allowed for shipment.	1 month	2 days
Process involved	5	2

Let any contractor take the above table, take any feature of any contract he may have, and see whether, in his opinion, he is likely to have more radical variables than he has in these two pieces of metal which go through the ordinary jobbing shop. The variations shown in this table are comparatively simple, compared with what actually appears in practice when complicated machinery is involved. And yet, the jobbing shop, if it is up-to-date, keeps accurate track of all of this work, and has standards by which each piece of work can be gaged. In many of the shops, however, standardization work has not been carried on, and here you find cases of extremely high overhead, and many of them have no idea whatever as to what their overhead amounts to. They are being continually compelled to purchase new equipment which depreciates at the rate of 50 per cent a year when the job for which it was purchased has been completed, and most of the profits will be found to have been tied up in this depreciation and completely wiped off the books.

Construction Problems Not Different.—Many contractors are in exactly the same condition as the old style jobbing shops. They maintain no general sales policy and sell for the opportunity of selling rather than for the opportunity of economical construction. Almost every contractor's yard will disclose equipment which has been tied up in the yard for two or three years, purchased for some special job with the idea of charging a large part of the cost of the equipment against the job, and never again used after the job was finished It is well to remember that some of the profits for that year have gone into the depreciation account which maintains that machine in the yard. When once the big problems have been taken care of, the handling of the smaller problems on construction are no more difficult than handling the same problems in a manufacturing plant. Take the cost system, for instance. The manufacturing concern which can take the total expenses for the year, divide them by the total output to determine the cost per unit, are extremely rare. We generally find that the same factors which interfere with accurate costs in the plant are the factors which interfere with accurate costs on a construction job. The big factors in both the construction job and in the manufacturing job is to first discover what factors can be standardized, and then to standardize these items. When these big problems have been cleared away, the remaining problems lose much of their significance.

Obtaining Standards Through Co-operation.—This leads us to the thought that it is perfectly possible for an association of contractors to set standards on a wide range of work, covering, not only the work of a single contractor, but the work of a very large group of contractors, such as that represented by the Associated General Contractors of America. When the standards have been set, the contractor may then determine the efficiency of his work as measured against these definite standards, and thus determine the weak spot in his own organization. These standards are not easy to obtain, nor is it practical, on account of the high cost involved, to obtain them on every class of work; but on such classes of work as brick-laying, form-building, some types of excavation, and other similar operations where an application is almost universal, it would certainly be of great benefit to general contractors to be able to have some standards by which they could measure their performance.

Standardizing Methods and Equipment.—Nor does the subject of standards need necessarily be confined to costs. In fact, one of the great benefits of the standardization of costs is the opportunity that it affords for the standardization of methods and equipment. At the present time, about the only basis that a contractor has for judging the utility of different types of equipment are the claims of the salesmen who sell the equipment. It certainly is reasonable to suppose that different types of equipment have a legitimate field to which they are adapted. If, through a careful research, it were possible to show the varying efficiency for each class of equipment under different conditions, the contractor would very probably save a considerable amount of money in the purchase of equipment through this knowledge of the demands in his own business. Yet in most cases, this would be a comparatively simple problem if applied to a large association of contractors.

Cost finding methods form another possibility of standards. With standard cost-finding methods, it would be possible for large groups of contractors to co-operate in the cost-finding work, and thus save a large amount of money in clerical work and in mistakes, due to faulty cost-keeping methods. In fact, in all problems which contractors have in common, it is altogether possible to set standards by which each man may gage his own performances and perhaps profit thereby.

Setting Blood Albumin Glue in a Kiln

The high water resistant qualities of blood albumin glue would make it very valuable for gluing thicker stock than plywood, when such stock is to be used under moist atmospheric conditions. An obstacle in the way of using this glue in ordinary joint work, however, is the fact that to coagulate and set it a temperature of 160° F. or more is required. In the manufacture of plywood with blood glue, the joint is made in a hot plate press, but this method is not feasible for heavy stock.

Recent experiments at the Forest Products Laboratory, Madison, Wis., point to the possibility of setting blood glue satisfactorily in a kiln. Heavy blocks were glued up with blood glue in the usual manner and put under pressure with retaining clamps and I-beams. They were then placed in a kiln and subjected for several hours to a temperature of from 175° to 200° F. A relatively high humidity was maintained in order to prevent loss of moisture from the blocks and an accompanying decrease in the pressure.

When the glue was applied to cold wood, from 15 to 18 hours in the kiln were required to set the glue. When the wood was heated to 150° F. before gluing, the length of time the stock had to be left in the kiln was much reduced. Two hours at a temperature of 200° F. were found sufficient to set the glue in blocks 7½ in. thick, consisting of 3 laminations.

Severe soaking and drying tests were afterwards given these blocks, and except for slight checking on the unprotested ends, the glue line remained intact. The shearing strength (on black walnut blocks) previous to the soaking tests averaged 1,670 lb. per square inch, with 80 per cent wood failure. When tested wet after soaking for 3 days they gave an average strength of 1,280 lb. per square inch, with 42 per cent wood failure.

The Housing Situation

Two bills designed to relieve the great national shortage of housing facilities have been introduced in Congress by Senator Wm. M. Calder, who by the way, was formerly a contractor. One of the bills provides for the creation of a home loan banking system that would make available at least $2,000,000,000 of assets for building purposes. The other bill provides for the exemption from taxation of the income on mortgages on real estate. In an address before the Senate on Aug. 8 Senator Calder in outlining the purposes of these bills, presented much interesting information on the present building situation. The matter following is abstracted from his address:

Small Profits for Lower Prices.—That there is a great national shortage of building is questioned by none. Building, after all, is a part of the war debt. It must be paid after the war is over at an increased cost, paid for in the cost of building or in rent or in the general high cost of living through the shortage of facilities.

Authorities offer no encouragement that there is an approaching lowering of cost, the consensus of opinion being that we are all subject to influences beyond our control—the world shortage of men, materials, and plant, heavy tax burdens, and foreign political complications.

Lowering of prices through the curtailment of exports or the increase of imports seems impossible at the present time. The only avenue remaining is the lowering of prices through increasing production.

The shortage of man power in the country points to the necessity of improved national facilities of every description. It is to be hoped that we are entering upon an era of industrial development which in effectiveness will outrun that occurring from 1865 to 1890, when machine methods replaced hand methods and tonnage production replaced pound packages.

We are the wealthiest nation in the world, wealthier than five of the next wealthiest nations combined. Our wealth is in the neighborhood of $265,000,000,000. There is no nation on the face of the earth with so large and homogeneous a population. The moral characteristics of our people have been quietly but unmistakably indicated by their response to the draft and to the war loans.

It is said that we already have more than one-half of the tools of industry of the entire world, and these, together with our remarkable resources and with the spirit of American hustle, have made possible a higher standard of living in this country than in any part of the globe.

Now that we are facing a shortage of labor and commodity, let us improve our tools of industry and develop our national resources, for our assets are surely ample, and let us improve our credit facilities for necessary construction.

Material and Labor Prices in 1914 and 1919.—Prices have been so high that many men have been afraid to undertake construction work. In New York City rents have increased 50 per cent, and the cost of building houses generally, as compared with four years ago, has increased at least 80 per cent. Let me point out the difference in the price of material and labor in New York City between 1914 and 1919, and this same ratio exists throughout the entire country.

WHOLESALE PRICES BUILDING MATERIALS, NEW YORK MARKET.

	Averages, for 1915.	July, 1919.	Increase. Pct.
Lime, common, per barrel	$ 1.24	$ 2 70	118
Cement, per barrel, net	1.03	2.05	99
Common brick, per thousand	5.94	16.00	170
Sand, per cubic yard	.50	1.25	150
Gravel, per cubic yard	.85	2.00	123
Crushed stone, per cubic yard	.85	1.75	106
Linseed oil, per gallon	.56	1.90	240
White lead in oil, per pound	.07	.13	86
Structural steel, per hundred-weight	1.46	2.72	86
Hemlock, base price per thousand	[1]22.50	40.00	78
Yellow pine timber, short leaf, per thousand	[1]22.50	42 00	87
Yellow pine, long leaf, per thousand	[1]28.00	50.00	127
Spruce timber, per thousand	[1]28 00	48.00	71
Window glass, per 50 sq. ft.	2.635	[2]6.20	136
Plate glass, 5-10 sq. ft., per square foot	.25⅛	[2].51	113

[1] July, 1915. [2] April, 1919.

UNION WAGE SCALE, BUILDING TRADES, NEW YORK CITY

	July, 1915	July, 1919.	Increase Pct
Carpenters, shop work	$ 4.00	$ 6.00	50
Carpenters, outside	5 00	6.50	30
Bricklayers	6.00	7 20	20
Cement masons	5.00	6 50	30
Composition roofers	3.50	5.25	50

Electrical workers	4.80	6.00	25
Engineers (hoisting)	6.00	7.00	17
Marble cutters and setters	5.50	6.50	18
Metallic lathers	5.30	6.00	13
Painters	4.00	6.00	50
Plasterers	5.50	7.25	30
Plumbers	5.50	7.00	27
Roofers and sheet-metal workers	5.00	6.00	20
Slate and tile roofers	5.50	6.50	18
Steam fitters	5.50	7.00	27
Stone cutters	4.50	6.75	50
Stone masons	4.80	6.50	35
Stone setters	6.00	7.00	17
Tile layers	5.50	7.25	30
Woodworkers, per week of 48 hours	18.00	27.50	53
Hod carriers	3.25	5.50	69

Average increase about 39 per cent.

Present Problems of the Building Industry.—The man engaged in the building industry today faces an entirely different problem than he did four years ago. During the war the policy of the Government was to divide its work among the different concerns in the same line, in proportion to their capacity to perform. There was a fixed price and a fixed profit. There was little or no competition. It was a matter of collective bargaining. The prices of a given article were practically the same, no matter from where or by whom quoted. Today one must pay practically the same price for what he buys no matter who sells it to him.

During the war we abolished the economic law of competition, and in its place have created a system of co-operation where men in every line of industry are assured a profit on their output. This is all very fine in theory, but what about the ultimate consumer? The man who builds houses today not only competes with other men who build under the same condition but with men who have old houses for sale, houses built when prices for the material and labor that went into them were little over half what they are at present, and while this era of high prices has made large profits for those who were wise enough to purchase houses under old price conditions, the man who builds houses today runs a great risk of having difficulty in disposing of them unless they are unusually attractive and different in type from those built in prewar times.

No one will buy a new house when he can get an old one nearly as good as new for very much less in price. The problem is, how best can we assure the builder a profit reasonable enough to induce him to go to work. In every city in the nation we are organizing associations to prevent profiteering in rents. That man is entitled to little consideration who will take advantage of present conditions and raise rents abnormally, but at the same time recognition must be given to the change in conditions, and the man who is compelled to increase his rents in keeping with larger carrying costs must be distinguished from the profiteer. If we are going to give any encouragement to the builder of new houses; if you are going to bring about a condition whereby rents will be stabilized, then you have got to give the man who takes the risk of building under such conditions every possible assistance.

On every hand we hear men argue that the workmen of the nation should have a better understanding with the employer, and that there should be a division of profits. I am for all of these things, but there is a degree to which co-operation and collective bargaining can go which may completely destroy the entire business fabric, and unless a way is found to prevent abnormal profits in building materials, thereby tremendously increasing the cost of production, then there must be no complaint against high rents and greater prices for the sale of the finished building. My own opinion is that we are not, for many years, going to have any cheaper construction. While it is true that the wages of workmen are high, still, in comparison with the things these wages purchase, they are not too high. There is no evidence of the necessities of life being materially reduced in price.

$4,000,000,000 Worth of Houses Needed.—In the United States every year there is need of approximately $3,000,000,000 worth of building construction to meet the needs of the country. Of this total perhaps $2,000,000,000 worth is required for the housing of the people, the rest being used for industrial and amusement purposes.

Today in the United States we are short nearly $4,000,000,000 worth of houses for our people to live in. We are something like a million houses behind the need. And for that reason those who have made a business of the construction of houses should have no misgivings about the beginning of construction despite the high prices. Every assistance should be extended to enable our people to build or buy their own homes.

The Outlook for Research in America*

By NEVIL MONROE HOPKINS, Ph.D.
Research Engineer, Washington, D. C.

America now undoubtedly stands upon the golden threshold of her greatest era of industrial research, invention and development. Will she profit by her powerful strategic position, and develop her full possibilities as the horrors of the great war fade into gray ghosts of the past?

Germany, undoubtedly the greatest organized research nation in the world before the war, has enjoyed her ascendency, and now, with prompt and efficient action, it is possible for the United States, or England or France, to lead for all time in research and discovery.

If we are to lead, we must not lose sight of the fact for a moment that great German committees are now preparing elaborate programs, and with proverbial German foresight and thoroughness for organized research again, and industrial warfare.

The Educational Requirements for Research Work.—It is now in the field of peace research that we should develop efficiency, not only in the inventor, but in the men who sit in judgment.

Dr. W. R. Whitney, a famous American research chemist, states: "We are generally superficial. The interesting lives of a few exceptionally able American inventors have led us to overprize engineering short cuts. We are patenting inventions at the rate of nearly 50,000 a year, but very few Americans are advancing the sciences at all."

Dr. J. S. Ames, an equally famous physicist, writes: "One illustration of this may suffice; one government board, with whose activity I am familiar, has had submitted to it in the course of the year 16,000 projects and devices, proposed by so-called inventors; of these only five had sufficient value to deserve encouragement. I have nothing but admiration for those 15,995 men, whose disappointment must have been keen. Most of them were more than willing to give their inventions freely to the Government. The point I wish to emphasize is, that the ability and knowledge required in waging this war successfully are not those possessed by any body of men except those with a profound knowledge of science and of scientific methods. The problems are too complicated. It is true that with the help of trained technical men we will get better engines, better explosives, better guns, and for these we should be truly grateful to our much-boasted American genius. But, consider a problem like this: to devise a light signal, which can be used by day or by night, and which will be absolutely invisible to the enemy. Who can solve that? The answer is obvious only a physicist."

Superficial Invention vs. Scientific Research.—It has been said that America has never been a nation of research in the profound scientific sense, but rather one of superficial invention. This statement has been resented, but more from patriotic impulse than from a careful analysis of the history and status of the subject.

Of course we have had quite a number of brilliant and profound American research scholars in some of our older institutions and lately during the war, ranking easily with any in the world, but speaking in general and considering the vastness and youth of the country, the field of true research has not yet been scratched

The shock of the great war just closing has without the slightest doubt been one of the greatest awakening influences our country has ever experienced and the more general spirit of real research has begun to come in for its share of development.

If we are young, and if we have been neglectful and even, with certain exceptions, stupid and short-sighted, there is now before us the great opportunity to make amends with full and telling force.

"The time has come," writes Dr. J. S. Ames, "for America to recognize the usefulness of the scholar, the thinker, the investigator of science. All the other countries of the world have done so long since."

The Spirit of Research in European Universities.—Since the writer's early education was received in schools in

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*From an address presented before the Engineers' Club of Philadelphia and printed in the August [illegible] of the club

France, England and Germany, the spirit of painstaking research in the universities and even in the high schools abroad was evident, and naturally made its first and lasting impression. In Germany, under compulsory education laws, within the black-white-red painted boundary posts, so familiar to those who have visited and studied the Empire, I remember that the spirit of textbooks and inquiry into the facts and forces of nature were so strongly fostered that the boys in the streets of German cities would often know the names of great scientists and other renowned scholars, and not the names of the strong men who toyed with massive weights in the public squares, or the national gamesters.

I mention this to bring out the fact that Germany has never been a nation of sportsmen, but rather one of abnormally close and painstaking application, and when I was a student in Munich, I could not fail to observe and record how morbidly close the German stuck to his studies. No engineer who has been to Germany and studied and traveled there can fail to appreciate that her great strength during the war lay in the foundation of her organized research, and that in the absence of a true and fair sporting spirit, she was without conscience as to ways and means.

But she was devilishly thorough in the theory and practice of her research methods. Here is but one incident which will illustrate the point. In a recent conversation with the president of an American steel company with whom I had to do in the manufacture of war munitions, he informed me that his supply of vanadium for the making of vanadium alloy steels had been cut off from the supply in South America through the poisoning of the llamas employed in bringing the vanadium ore down through the hazardous passes in their mountainous country by agents of German scientists.

French and English as Compared with German Technologists.—It has been a mistaken notion that the French and the British did not produce research technologists just as keen and just as able as Germany, even in the most complex organic chemistry of dyeing, which has often been regarded as a German art.

When the great art of dyeing was young, the academic and practical honors were by no means all Germany's.

In the famous international exposition in London, in 1862, the chemical genius in producing intricate coal-tar products was mainly French and English. Here the United Kingdom received 12 medals by the International Jury of Award, and France received 21, and Germany and Austria together only 12.

The genius and skill were all there with France and England, but for some reason or another they did not sustain the competitive commercial spirit.

Research Efficiency vs. Protective Tariff and Boycott.—If we are now to acquire research efficiency, we cannot lapse into stupid indifference, and continue to elect corruptible or anti-American politicians and place them at the helm of affairs of state, industry and commerce. I am inclined to think that we are awake now, and that we will not be caught napping again. Dissemination of German gold as a powerful part of German propaganda before the war to admit German dyes and dyestuffs, is now one of the many well-established facts which have been uncovered, and if our eyes are really opened we must prepare at once to fight educationally and scientifically, instituting an intensive and aggressive campaign. We have learned to our mortification that no defensive bulwark, in the form of a tariff, no matter how high, will answer as protection. We must equip for the battle and stand upon our feet and fight to capture and to hold. Reliance upon protection, or hoping to thrive on the boycotting of German goods now that the war is won, would be an exexcusable lapsing into old lamented methods. I can here testify first hand, from contact with many American manufacturers, that a great majority of them belittled academically trained technologists and when they employed them at all, they were regarded as a highly expensive and speculative investment. While Germany was building some of her greatest and most substantial industries, destined to shine as unchallenged examples to the entire world, Great Britain and America did not appreciate the soundness of their slumbers. In old England, I have been told that chemists were not favored, because, "knowing something about the business, they might influence it in some way."

The Chemist as a Commercial Asset.—Sir Joseph Lamar pointed out that England had no use for chemists, but that Germany regarded them as the highest of assets, and that the present war is one of chemists, and that the coming peace will likewise be one of chemists. Professor Armstrong wrote in the London Times his views and experiences in England also. "Though I have 50 years' experience as a chemist," he writes, "particularly in connection with the materials being used in the manufacture of explosives and of natural and artificial organic products, I have never been consulted; and the only request for my assistance that I have received, since the outbreak of the war, came from a German gentleman, long since naturalized as a British subject. No doubt I am properly regarded as merely a retired professor, but I know highly competent younger men among those trained by me who are equally unutilized."

The industrial plan in Germany was ever fundamentally based upon research and an organization designed to expand against all the counter-forces of more inert nations, until she achieved her policy of world domination. And in this grand scheme of organization for military victory as well as industrial control, it may now be seen how the university played a most important part, and how the professors, the Herr Professors, the Herr Doctor Professors and the Herr Doctor Lecturer Professors, and the Herr Doctor Lecture Research Professors threw their might into the great balance of her progressive scheme.

How Shall We Develop Our Full Scientific Powers?—If we make a broad and careful analysis of the very complex conditions under which we live, it is certain that we will have come to the rather inspiring conclusion—

"That the World Knows Not Its Greatest Men."

Why doesn't the world know its greatest men? From what ranks may be expect them? How can they be introduced?

It will be the endeavor, by incorporating the views of others who have given much attention to the subject, to answer as far as practicable these vital questions. There are in this connection at least two methods of classifying men—by reputation, and according to natural gifts. The first classification is by reputation and is a misleading one, and the second classification is obviously very difficult of achievement.

A man's success is many fields depends upon opportunities, and upon natural power of intellect, and sometimes he must possess both of these factors.

It is where small men become "great" through opportunity alone that it is regrettable.

The saying "The survival of the fittest" has always been a very irritating one to me, since many, many cases of the survival of the unfit have come under notice. Since according to our quotation, "The greatest admirals have gone down in their ships" and the soundest thinking minds have not come to the light of recognition, if in dealing with the subject I take a different point of view from the one of customary praise, one which I believe to be better for the immediate future of our country, I hope that I may not be misunderstood as unsympathetic or in the least unpatriotic.

Few Profound Thinkers During Last 300 Years.—Professor Simen Newcomb, the pre-eminent genius of American science, wrote relative to the comparatively few men who have demonstrated the profoundest ability in the field of research: "It is impressive to think how few men we should have to remove from the earth during the past three centuries to have stopped the advance of our civilization. In the 17th century there would only have been Galileo, Newton, and a few other contemporaries; in the 18th, they could almost have been counted on the fingers; and they have not crowded the 19th. Even today, almost every great institution for scientific research owes its being to some one man, who, as its founder or regenerator, breathed into it the breath of life.

"If we think of the human personality as comprehending not merely mind and body, but all that the brain has set in motion, then may the Greenwich Observatory of today be called Airy; that of Pulkowa, Struve; the German Reichsanstalt, Helmholtz; the Smithsonian Institution, Henry; the Harvard Museum of Comparative Zoology, Agassiz; the Harvard Observatory, Pickering."

But Professor Newcomb was listing great institutions and their subsequent world influences as well as men perhaps, so under this interpretation, I may without presumption add the following names in alphabetical order as standing for in many instances equal brilliance with those supplied: Archimedes, Avogadro, Becquerel, Berthelot, Bessemer, Bell, Brashear, Cavendish, Charles Coulcomb, Crookes, Davy, Dumas, Daguerre, Darwin, Dewar, Dulong, Edison, Ericsson, Faraday, Franklin, Gay-Lussac, Henry, Joule, Kelvin, Kepler, Langley, Lavoisier, Le Chatelier, Myer, Mendleeff, Maxwell, Morse, Newton, Newcomb, Oersted, Ohm, Pascal, Ptolemy, Pasteur, Priestly, Ramsay, Rayleigh, Thompson, Tesla, Tyndall, Volta, Wheatstone.

Why Does Not the World Know Its Greatest Men?—The sooner the average inventor can abandon ingrowing habits of thought, the more rapid will be his development. There are many able scientific men in America whom the world should, and would know, if only they could be relieved from the strain of heavy routine executive work, or be allowed, or forced out from the narrow confines of their own laboratories and shops, and mentally stretch and look about them and compare notes with others. There is another class who have been accustomed to the praise and applause of immediate friends and misleading admirers in a little community, and who do not appreciate how limited are their horizons, and remain self-satisfied and complacent in the often damaging applause.

Where Do Men of Genius in the Various Activities Come From?—Sir Francis Galton selected 100 Englishmen of well-marked meritorious achievement, and after carefully tracing the origin of each man, found that only 4 per cent came from the manual laboring classes. My analysis of this poor showing in the laborer is lack of education and mental training of those who work long hours in the shops and factories. I believe the universal introduction of the 8-hour day will go a long way to correct this lack of opportunity for development, and I would suggest that such workmen who may have more time under this 8-hour day, spend their leisure or golden hours to better advantage than agitating for a 6-hour day, a 4-hour day and what not. I would advise his studying some well established and sound constructive subjects, instead of, especially at this time, being led or coerced, by soap-box orators, or selfish labor delegates, with no perspective or by I. W. W. leaders into dabbling in socialism or any other vague political or so-called economic movement.

Of course I would not expect all workmen who may receive this advice to follow it, but I am confident, from an intimate knowledge of the plodder in sound well-established arts and sciences, that if he devotes his time to fighting his way through acquiring knowledge, instead of through hate and dynamite, he will in America reach a far richer goal in a far shorter time.

Monsieur Odin made a life study of 6,000 Frenchmen of eminent attainment, and his alignment with the English experimenter was fairly good, showing a parallel of 9.3 per cent in the production of genius for the laboring classes. Monsieur Odin lists the results of his inquries as follows:

	Per cent
Nobility	25
Government officials	20
Liberal professions	23
Bourgeoisie	11
Manual laborers	9.3

This table was so forceful in its lesson that its tabulator exclaimed:

"Genius is in things, not in men."

I am led to believe that genius among American laborers will show a considerably higher percentage, that intellectual attainment as evidenced in invention and discovery will be more conspicuous than in either England or France. I think that this may be due to a considerable extent to our many moderate priced and excellent semi-technical magazines, as well as the elaborately illustrated instruction sheets sold by the several correspondence schools.

How May Men of Genius Be Developed from Among the Laboring Classes?—Ultimately, in America, I am very sure with the more thorough education of the children that drift into the great manual laboring classes, that a much higher percentage of laboring men, and women, will rise to high positions and even fame. There is the best of such material here to work upon, especially the children from farms and little towns who filter through the schools to the factories.

At the present time, however, about 90 per cent of American school children stop their studies with the grammar school. If their schooling, and the accompanying training of the mind, could be continued for another year or two, there is but little doubt of their ultimate increased chances to rise from the ranks of the laboring classes, a great army whose opportunities and influences in America have already been enormously increased by the fortunes of war.

To develop the intellectual and inventive powers of those who work in the shops, I would recommend constructive study in the sound arts and sciences as already outlined, and travel. Do not be prematurely shocked at this last suggestion, for I do not mean that the workman should travel around the world or even elaborately in his own country, but that he should travel from one field of activity into another, whereby he may gain an insight into many industries.

Many Men of Genius Lost Through Press of Routine Work.—Now, on the other hand, why don't we produce better inventors and more geniuses from the classes with more comprehensive educations?

De Tocqueville wrote concerning America in this connection: "It must be admitted that among the civilized peoples of our times, there are few in which the higher sciences have made less progress than in the United States." And continuing he adds: "I consider the people of the United States as that portion of the English people which is charged with the exploitation of the forests of the New World, while the rest of the nation, enjoying more leisure and less preoccupied with the material needs of life, may devote itself to thought and to the development of the human mind in every field."

It is true that this statement of De Tocqueville was written some years ago, but he points out a truth still more or less applicable to conditions today in the pursuit of wealth with its strenuous preoccupation.

Tyndall wrote also in this connection as follows: "If great scientific results have not been achieved in America, it is not to the small agitations of society that I should be disposed to ascribe the defect; but to the fact that the men among you possess the endowments necessary for profound scientific inquiry, are laden with duties of administration, so heavy as to be utterly incompatible with the conditions and tranquil meditation which original investigation demands."

This criticism of Tyndall still holds in full force today, and is undoubtedly one of the prime reasons why America doesn't know its greatest men—at least its greatest scientific men.

A rough-and-ready life in a country to be conquered, however, has great developing value if the worker is not overworked.

Youth on a farm usually excels in later years, and I think, as far as invention goes, the stimulus is due to the fact that a self-contained farm is in a sense a complete manufacturing plant, a laboratory and a forum of combined activity of mind and body. In earlier days every farmstead was a very complete and self-contained manufacturing plant, from the fabrication of candles to the spinning of the wool raised at hand and the making of the rough homespun cloth, the driving of the well, and the crystal water from its depths, the meat consumed, and the poultry and the eggs, the butter, milk and cream, were all products of the self-contained establishment.

Charles Josiah Gilpin depicts most beautifully an overworked farmer, possibly the father of little James Watt, who devised the great steam engine from the teakettle on the stove: "The arena of country life, labor and struggle, where the farmer and his family achieve the primary habits of thought and action, is the farmstead. The farmer," continued Gilpin, "he is the man, hoe in hand, with bent back, striking blow after blow at the weakest point in the earth's crust, pulling upward, loosening the earth's grip upon a portion of soil, lifting it for a moment, and finally turning it upon its face. This momentary mechanical victory is repeated, clod by clod, yard by yard, hour after hour, day after day, all through the season of soil preparation. Unremittingly looking his earth antagonist in the eye, the land worker gives and takes—gives his blows and takes the after-effects into his own body and soul." How can such a man, however he may be intellectually endowed, rise above the routine and bodily fatigue, and yet we see the same principle in the hard routine work of the scholar, forced into finance and accounting, duties of management and administration, and if he is rich in worldly things, is he the owner, or do these worldly things own him, body and soul?

Can a man today own a million, or does the million own the man?—and here I am speaking of the man with the inventive and research type of mind.

Conclusion.—There will always be the passion for acquiring, in spite of socialism, anarchy and bolshevism for it is, according to the psychologists, a natural impulse.

"It is impossible," says Morgan, in his work upon ancient society. To overestimate the influence of property in the civilization of mankind. It was the power that brought the Aryan and Semitic nations out of barbarism into civilization. The growth of the idea of property in the human mind commenced in feebleness and ended in becoming its master passion. Governments and laws are instituted with primary reference to its creation, protection and enjoyment. It introduced human slavery as its production; and after the experience of several thousand years it caused the abolition of slavery upon the discovery that the free man was a better property-making machine."

Mark this last sentence: that the free man was a better property-making machine. Does this not indicate that if more of our men were freer from the slavery of routine over burdensome duties, and if he, the college professor, for example, were better paid, he would make a better property-making machine?

Although I sympathize to a great extent with labor and the class of men in the labor unions, what of our clerks, bookkeepers, and draftsmen, our engineers, scientists and teachers?

They, too, should be as carefully considered and their nerves and working power safeguarded, for is not the conservation of balanced working power the most precious possession of a nation?

Of what practical use is our boasted enormous American labor without the directing genius of the man who works upon the frontiers of human knowledge and turns theory into practice?

The outlook for research and development in America depends upon how we are disposed to help the type of men who bring to us the progressive thought and the balance in the working power.

Business Training for the Engineer*

By A. MARSTON

Dean of Division of Engineering, Iowa State College, Ames, Iowa

I believe that the demand for business training for the engineer is widespread throughout the engineering profession. In part it is a more or less unconscious revolt against the conception so common in the business world, that the engineer is merely a highly skilled mechanic, destined by fate and custom to serve only as an employe of some profit seeker.

Reasons for Present Demand for Business Training for Engineers.—The new thought is, why should not the engineer be his own employer in great industrial enterprises of an essentially engineering character? Why should he not be the organizer, the president, the manager of great industrial corporations rather than a mere hired expert?

Another cause for the present demand for business training for the engineer is the general dissatisfaction among employers of engineers with the product of our engineering courses of study. Methods of instruction have become standardized to such an extent that it is almost as great a sacrilege for any engineering college to deviate from the general practice as it was for the ancient Egyptian draftsman to vary a line from the symbols in representing Pharaoh. Of engineering educators it truly may be said that we have looked upon our work and we find that it is good, but we have no inquisition at our command to put down the numerous unbelieving heretics who keep on pointing out defects in the results we secure.

The engineer employer needs, above all, men who are qualified for successful executive responsibilities in great industrial undertakings, and he is not satisfied with the product which our engineering colleges are sending out.

Even before the war then, engineers and engineer employers were demanding business training for the engineer. Since the close of the war comes Uncle Sam himself to tell us that the imperative post-war needs of the United States require great engineer leaders, with sound business training, to develop our great mechanic arts industries for economical and profitable production, transportation, sale and use, at home and abroad. Patriotic duty to the country now furnishes an additional reason for the introduction of business training into every engineering course as a fundamental part thereof.

The Object of Business Training.—The schools of commerce are coming to call upon the colleges of engineering for some informational training of commerce students along engineering lines. This call should be heeded, but it is not believed that the great mechanic arts and trade needs of the country can be met adequately by superficial descriptive engineering training of business men to such extent only as to enable them to read with fairly intelligent understanding the reports of hired engineer experts. What we need are great engineer leaders, men who possess the highest engineering qualifications combined with great business ability, and who can conceive great mechanic arts enterprises, design their engineering details, build their greatest constructions, organize and direct their operations, and who also can interest capital and deliver a fair profit to investors.

I take it that the principal object of all business training (speaking broadly) is financial profit. Public utilities, for example, are successful from the business point of view whenever they make money for their stockholders, although they may poison a city with polluted water, furnish unsatisfactory light and power, cause the traveling public all sorts of inconvenience or ruin industries by insufficient or inequitable transportation facilities. Toleration of such shortcomings, it is true, might be unwise, but this would be because they might arouse antagonism, cause enaction of legal restrictions, decrease patronage, or otherwise operate to decrease profits.

In engineering, on the other hand, profit, though essential, is only one essential to be attained, and achievement in the successful utilization of the principles of the science of mechanics is the great object. The engineer has been trained to give primary attention to the scientific principles of design, to ingenuity in invention, to industrial organization for construction and production on the greatest scale and at the lowest cost.

In planning business training for the engineer we should not attempt to lower the great ideals of his profession. We should add business training to the engineer's equipment, not substitute it for engineering qualifications. We should qualify the engineer to take into account, with due weight in the solutions of his problems, the great questions of capital, labor, and profits, as well as the scientific principles of engineering theory and experience. The engineer's remuneration should no longer be left to be considered as a mere item on the cost side of the books of the enterprise.

Business Training as Required Work in Engineering Courses.—There are those who believe that the problem of how to provide business training for the engineer can be solved by creating a new branch of engineering to be called "Business Engineering," providing 4-year business-engineering courses supplementary to the course in civil, mechanical, and electrical engineering. Some schools of commerce, on the other hand, offer 4-year business courses in which a certain amount of engineering training is included in addition to their commerce courses.

Though not denying that they may serve useful purposes in some institutions, I do not believe that 4-year combined courses of either type furnish an adequate solution of the general problem of business training for the engineer. Manifestly, only a small fraction of the engineering students, on the one hand, and the commerce students on the other, can be expected to enroll in such courses. We already have too many special courses in engineering. The present tendency is toward broader rather than more specialized engineering training.

The only really adequate method for providing the business training now needed by engineers is to put it into the regular 4-year courses, as required work, to approximately the same extent as chemistry or physics. I earnestly believe that this should be done.

The business subjects should be restricted to simple, fundamental business principles. Economic science, accountancy, business law, corporation finance, industrial organization, and business psychology are examples. These subjects may be taught wholly in the school of commerce or partly in the college of engineering, according to local conditions. If taught in the school of commerce, turning this instruction over to subordinates should not be tolerated.

74 Per Cent Capacity of Fabricating Shops Contracted for in July.—The records of the Bridge Builders and Structural Society as collected by its secretary show that during the month of July, 1919, 74 per cent of the entire capacity of the bridge and structural shops of the country was contracted for.

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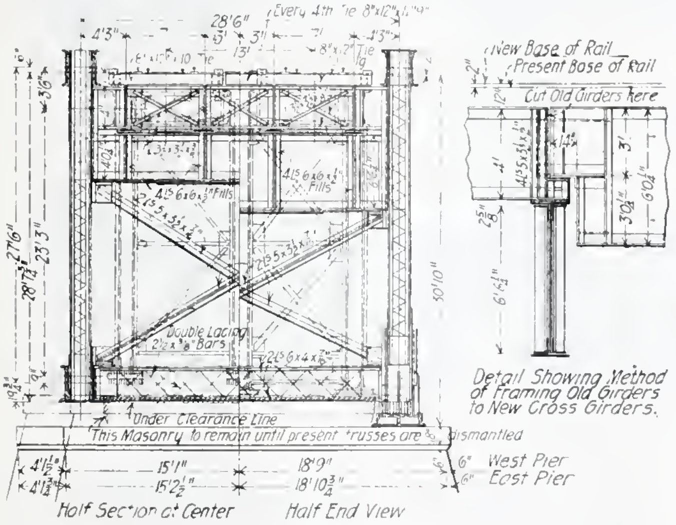
*Part of address delivered June 27 at the conference at Iowa State College on "Business Training for Engineers and Engineering Training for Students of Business."

Method of Rebuilding the Genesee River Bridge, Lehigh Valley R. R.

The bridge over the Genesee River on the Buffalo Division of the Lehigh Valley R. R. was originally designed for a so-called "Lehigh Valley" heavy grade engine weighing 126 tons (engine and tender), the axle load for the consolidation type engine being 40,000 lb., making the loading somewhat near Cooper's Class "E 40" engines. The details of the structure, too, were not as good as modern practice and heavier motive power would warrant. The bridge, built in 1891-1892, consisted of a pin connected deck span of 225 ft. length, and a deck plate-girder viaduct of ten spans, each 60 ft., two each 64 ft. and ten tower spans each 30 ft. long, with a through plate girder span over the Western New York & Penna. R. R. 58 ft. 4½ in. long adjoining at the west end, making the total length of the structure about 1,311 ft. The spacing of trusses and viaduct girders was 10 ft. c. to c. with three lines of trusses and girders for double track. The through plate girder was composed of three girders spaced 13 ft. and was provided with the usual floor beam and stringer floor systems; 8 in. by 16 in. wooden bridge ties placed directly on the upper chords carried the rails on the deck spans.

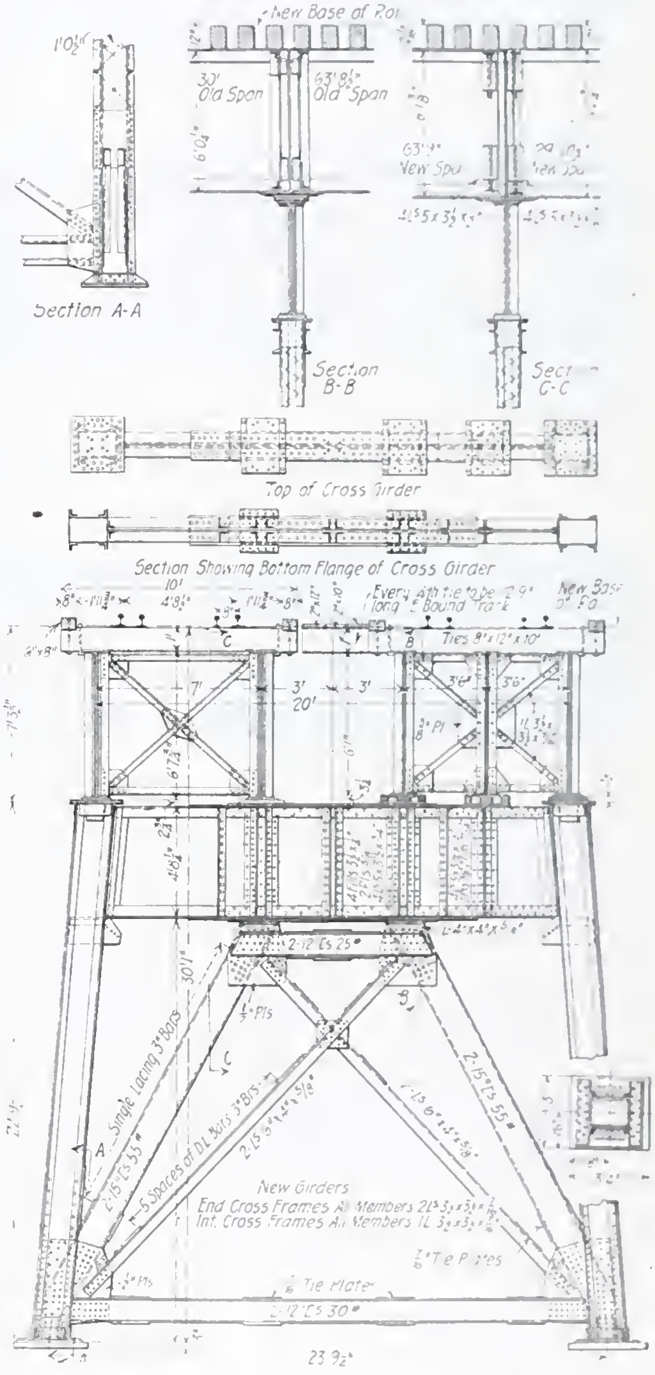


Details of Rebuilding River Span.

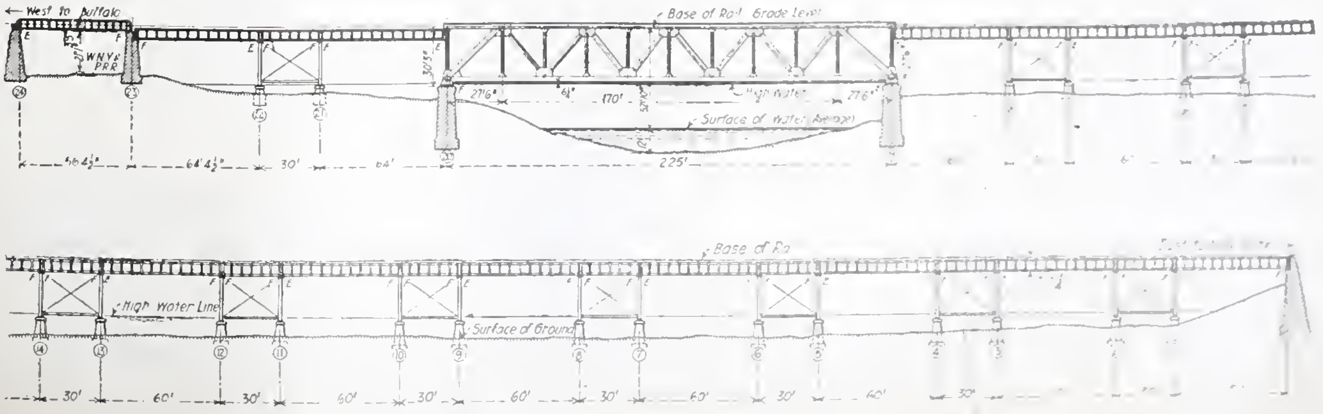
In the reconstruction to bring the structure up to the capacity of Cooper's E 60 loading (the present standard loading used on the Lehigh Valley R. R. main line bridges), the following scheme was adopted:

Raise the viaduct towers 3 in., remove the X-bracing of tower bents, and introduce inclined sub-posts, fastened to the foot of the main columns and supporting the existing cross girders at other end, move all existing viaduct deck plate girders (three lines) to the east-bound track, spaced 3 ft. 6 in. center to center, place two lines of new viaduct plate girders for the west-bound track, replace the 225-ft. pin-connected deck truss span with a two-truss riveted span, the trusses spaced 28 ft. 6 in. to permit of their erection outside of the existing trusses.

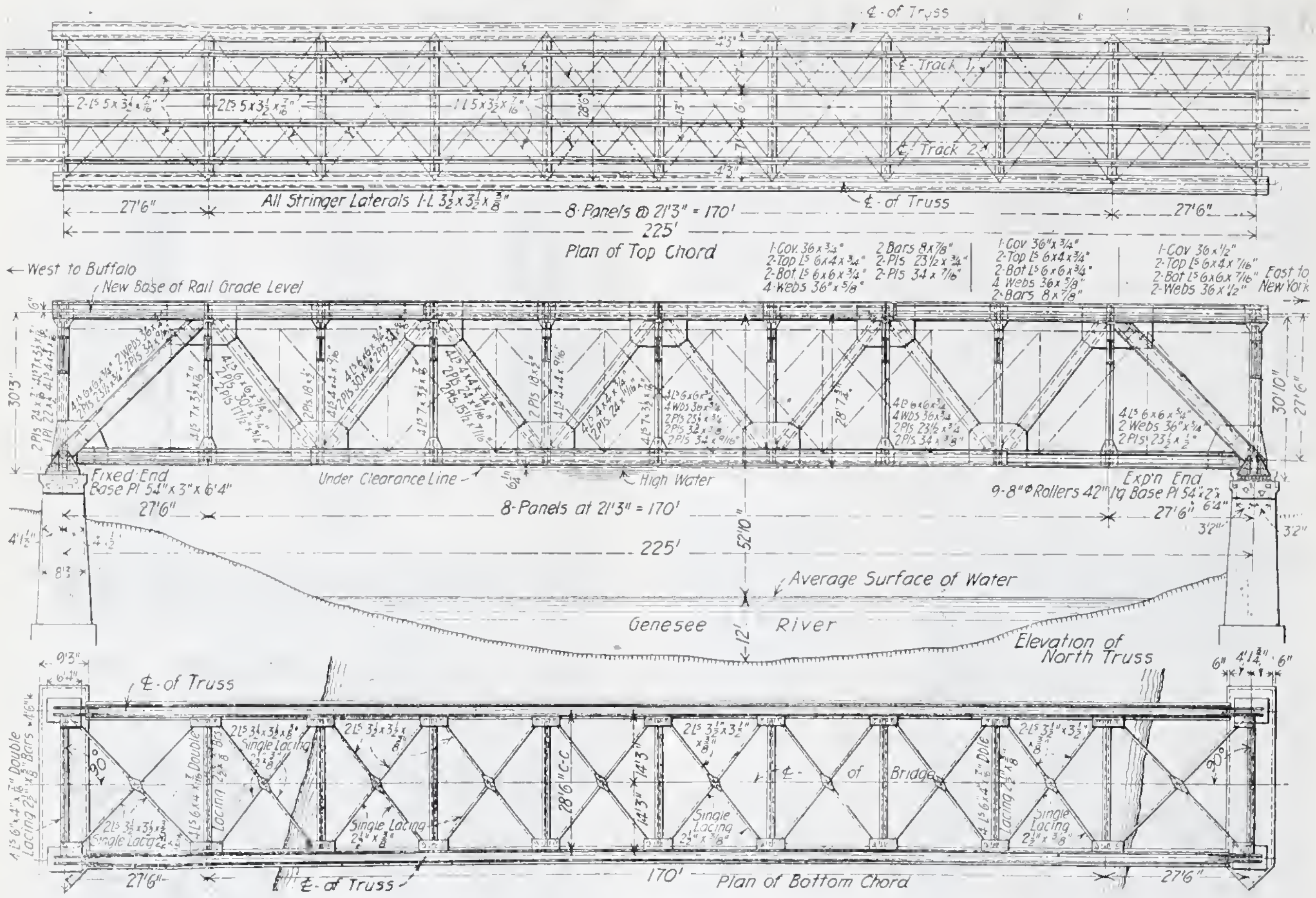
The new truss span is provided with a steel floor system placed below the top chord. The panels of the truss span were so arranged that the floor beams of the new span could be erected without interference with the posts and diagonal eye bars of the existing truss.



General Details of Strengthening of Towers.



General Elevation of Genesee River Bridge, Lehigh Valley R. R.



General Elevation with Chord Plans.

The extension of the piers of the river span to allow for under spanning of trusses and also the lowering of the bridge seats to provide for the increased truss depth adopted, were done by the railroad company's forces. Cofferdams, piling, concreting and reinforcing for this work offered no apparent difficulties, the new structure interfering very little with the old. Bond between old masonry and new concrete was obtained by cutting the masonry into steps, and by means of bolts in the old masonry. The reinforcing steel was "wired" to the bolts for anchorage. No changes were made in the foundations of the tower bents except to place a 3 in. bed plate under each column bearing.

To permit of continuous operation of trains during reconstruction, the work was subdivided into three stages. The first provided for raising of the existing viaduct towers 3 in., each tower of four posts being raised simultaneously. In this operation, the strengthening of the viaduct towers, placing the sub-posts, new cross bracing for bents, stiffening of cross girders were also done, under double track carload operation but under reduced speed. Run-off blocks, to provide for 3 in. break in grade were used only on the truss span.

The second step provided for single track operation of the east-bound track, for a total length of 2,500 ft. by means of cross overs.

During this stage of the work the contractor removed temporarily the north girders of the existing viaduct and placed the new girder spans, which were riveted together complete in the shop, beginning at the east and west ends of the truss span and working east and west. The new trusses of the river span, the floor beams, and as much of the sway and lateral bracing as cleared the old truss span, were also placed into position from pile bents and falsework erected for that purpose across the river. After the trusses of the new river span and the floor beam connections were riveted and the old center and south trusses, the spacing of which was too close to permit safe operation of trains without the stiffness from the old north truss, were braced against and tied to the new truss span, the old north truss and bracing between it and the old center truss were then removed, section after section, placing the new stringers for the west-bound track as fast as the removal of sections of old trusses permitted. During this operation the north half of the through plate girder span over the Western New York & Pennsylvania R. R. was also replaced, the new center girder, one side girder and the floor system being placed off center to the north, to clear the center girder of the old span.

The third operation provided for single-track operation on the west-bound track. Under this the old center plate girders of the viaduct were shifted southward for center girders of the east-bound track; the old north plate girders, which were temporarily removed, were erected as north girders for the east-bound track, making, with the old south girders, three girders for this track, supplied with new cross frames and lateral bracing, and set on new raising blocks resting upon and fastened to the old cross girders of the tower bents. During this operation also the remaining two old trusses of the river span were removed; the balance of the lateral and sway bracing, as well as the new stringers for the east-bound track, were placed in position and riveted, and the south half of the old through girders span at the west end was moved and the new south girder and floor system for this span placed into position and riveted.

After the ties and rails for the east-bound track were placed, double-track operation was resumed, completing the work of reconstruction of the bridge except for the painting of steel work, which was done during the summer of 1918.

The total weight of new steel used in the structure was over 3,000,000 lb. Considering the shortage of labor and extraordinary war conditions under which the work was done, better progress was made than anticipated. The work was commenced on May 1, 1917, and was completed Feb. 15, 1918, at a cost of $244,300.

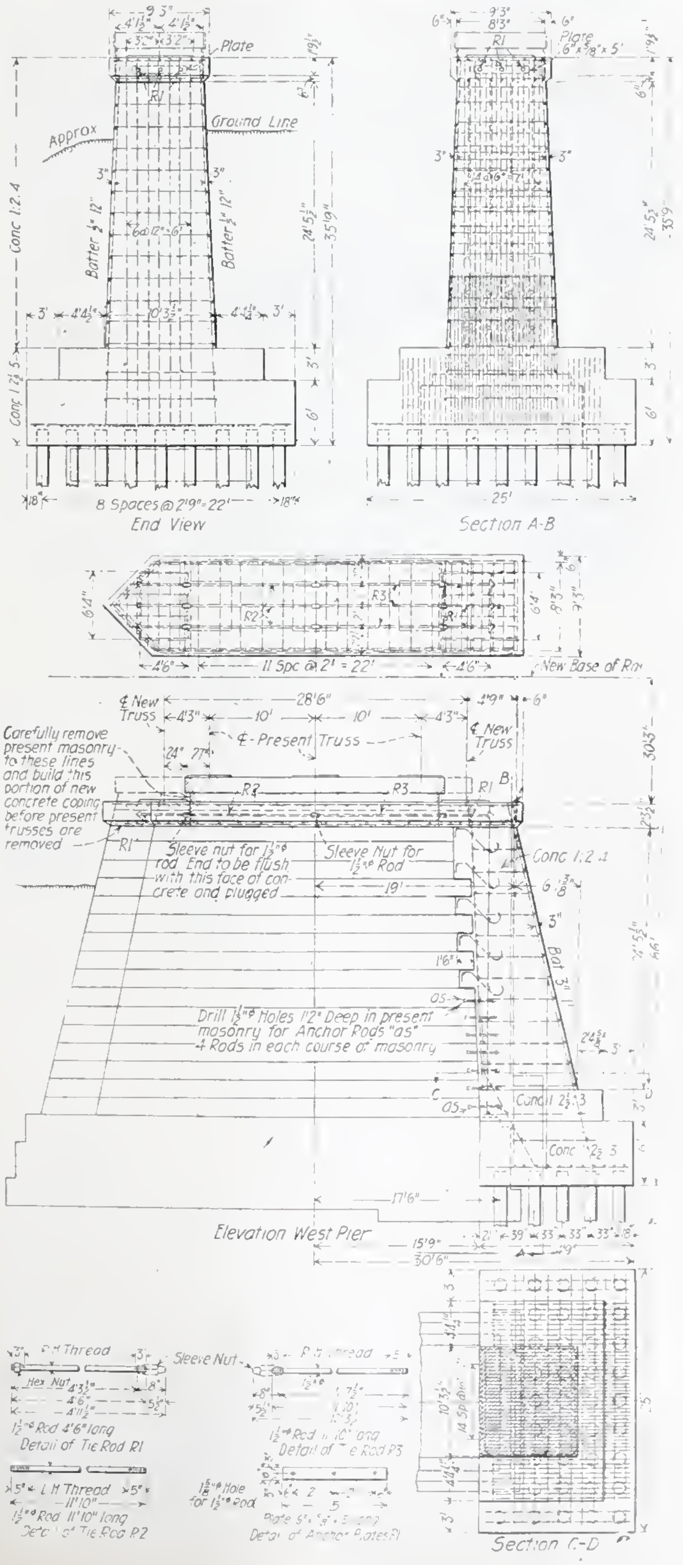
The Bethlehem Steel Corporation was the contractor for the superstructure. The structure was designed by the Lehigh R. R., George T. Hand, chief engineer; F. E. Scholl, bridge engineer. The latter furnished the material for an article in Railway Review of June 21, 1919, of which this is an abstract.

Pan Pacific Engineering Congress.—An engineering congress will be held at Weltevieden, near Batavia, Java, May 8 to 15, 1920. Following the congress there will be an industrial exhibition. The address of the secretary of the congress is Molenvliet East 3, Weltevieden, Java.

Standard Recommended Practice for Portland Cement Stucco

Stucco is indeed a live subject. There are no reasons why portland cement stucco should not be structurally sound, durable, and capable of giving satisfactory service with little or no outlay for repairs or maintenance. The recommendations by the Committee on Treatment of Concrete Surfaces of the American Concrete Institute, submitted at the recent annual convention of the Institute, are printed in Vol. XV, 1919, Proceedings are timely and it will pay architects and building superintendents and especially the owners, to recognize them.

The committee has enumerated the recommendations under separate headings, design, masonry walls, frame walls, materials, preparation of mortar and mortar coats.



Changes and Extensions of West Pier for Truss Span.

Under the design, stuccoed copings, cornices, and other horizontal surfaces are not recommended. Flashings are covered very thoroughly. Under frame walls, diagonal sheathing is pointed out to be uneconomical in labor and material. Metal lath needs better joining and fastening. Not enough test data are available to entirely eliminate wood lath. No changes to speak of are given under materials or preparation of mortar. Stripped, sand floated, sand-sprayed rough cast or splatter dash, pebble dash and exposed aggregates surfaces are described in detail.

The committee recognizes that a considerable amount of experimental work remains to be done before the best methods of producing these finishes can be specified, but hopes that by hearty co-operation of interested agencies this experimental work may soon be undertaken and carried to a successful conclusion.

Application of Stucco in Masonry Walls. As the committee was of the opinion that walls of hollow tile, brick, concrete block, and similar materials were superior to frame construction for the application of stucco, a change in the usual order of the paragraphs under "Structure" was recommended. The committee also considered it advisable to include somewhat more detail in the paragraphs relating to masonry surfaces. The following revisions in the latter group were accordingly recommended:

4. Tile.—Tile for exterior walls, columns, etc., should be hard burned, with dovetail ragged scoring. Tile should be set in cement mortar composed of one part cement, not more than one-fifth part hydrated lime and three parts sand, by volume. The blocks should vary not more than ½ in. in total thickness and should be set with exterior faces in line. Joints should not be raked, but mortar should be cut back to surface. Neither wire mesh or waterproofing of any type should be applied to tile walls before plastering. The surface of the tile should be brushed free from all dirt, dust and loose particles, and should be wetted to such a degree that water will not be rapidly absorbed from the plaster, but not to such a degree that water will remain standing on the surface when the plaster is applied.

5. Brick.—Surface brick should be rough, hard burned commonly known as arch brick. Brick should be set in cement mortar with joints not less than ⅜ in. thick, and the mortar should be raked out for at least ½ in. from the face. The surface of the brick should be brushed free from all dust, dirt and loose particles and should be wetted to such a degree that water will not be rapidly absorbed from the plaster, but not to such a degree that water will remain standing on the surface when the plaster is applied.

Old brick walls which are to be overcoated should have all loose, friable, or soft mortar removed from the joints, and all dirt and foreign matter should be removed by hacking, wire brushing, or other effective means. Surfaces that have been painted or waterproofed should be lathed with metal lath before overcoating.

6. Concrete.—Monolithic concrete walls should preferably be rough and of coarse texture, rather than smooth and dense, for the application of stucco. Walls of this type should be cleaned and roughened, if necessary, by hacking, wire brushing, or other effective means. The surface of the concrete should be brushed free from all dust, dirt and loose particles, and should be wetted to such a degree that water will not be rapidly absorbed from the plaster, but not to such a degree that water will remain standing on the surface when the plaster is applied.

7. Concrete Block.—Concrete block for stucco walls should be rough and of coarse texture, but not weak or friable. Block should be set with cement mortar joints, which should be raked out or cut back even with surface. Before applying the stucco the surface should be brushed free from all dust, dirt and loose particles, and should be wetted to such a degree that water will not be rapidly absorbed from the plaster, but not to such a degree that water will remain standing on the surface when the plaster is applied.

In the foregoing paragraphs attention is called to the degree of wetting of the surface, which is important if best results are to be obtained. Too dry a surface will absorb the water from the plaster coat before the latter has had time to obtain its set, whereas a surface which is completely saturated is likely to be covered with a thin film of water which will prevent proper bond of the plaster coat.

Stucco on Frame Walls.—The committee report contains the following remarks relating to the frame structure: The general paragraph on framing needs no revision except in regard to spacing of studs. The specified 12-in. spacing is perhaps desirable in some cases, as, for example, when wire or other type of non-reinforced lath is to be back plastered, but in general such close spacing is not required.

Good bracing of the frame is important to secure the necessary rigidity. Bridging between the studs at least once in each story height is recommended whether the frame is to be sheathed or not. In the former case the bridging serves as a fire stop,* even if not necessary as bracing, and should be of the same size as the studs (usually 2x4-in.). In the back-plastered type of construction where sheathing is not used, bridging is required for stiffening the frame, and should be 1 in. less than the studs in depth. It should be placed horizontally, and 1 in. back of the face of the studs, in order that the back-plaster coat may be carried past the bridging without break at this point. Diagonal bracing at the corners of each wall is recommended, especially when sheathing is omitted. Such bracing may be of 1x6-in. boards, 6 or 8 ft. long, let into the studs on their inner side in order not to interfere with the back plastering or the interior plastering. The length of the corner bracing will, of course, depend to some extent on the location of window or other openings.

When sheathing is used, it should be laid horizontally and not diagonally across the studs. The stucco test panels erected at the Bureau of Standards in 1915 and 1916 have demonstrated conclusively that diagonal sheathing tends to crack the overlying stucco by setting up strains in the supporting frame. This result is undoubtedly due to the shrinkage of the sheathing, and whatever benefit might be anticipated from the more effective bracing provided by diagonal sheathing appears to be more than offset by the shrinkage effect. Diagonal sheathing is also less economical than horizontal sheathing, both in material and labor.

Waterproofing of the faces of the studs in back-plastered construction seems to be ineffective and unnecessary, and its elimination is recommended.

The proper type and depth of furring is a question on which information is desired. If metal lath is applied over sheathing and the commonly recommended practice of filling with mortar the space between lath and sheathing is to be followed, there seems to be no good reason for using furring deeper than ¾ in. On the other hand 1x2-in. wood furring is widely used for both metal and wood lath, and there are good arguments both for and against this type of furring. The question of the proper length and gage of staples for metal lath is involved with that of furring. The entire subject needs investigation. At the present time the committee is not sufficiently well informed to recommend a change in the existing paragraphs of the specification, aside from reducing the depth of furring from ½ to ⅜ in.

Metal lath should be specified by weight rather than by gage, and should be always galvanized or painted. Galvanized lath is a good investment in most cases, and is to be recommended in preference to painted lath, unless the method of applying the stucco is such as to insure complete embedment of the metal, as, for example, in the back-plastered type of construction.

The results of tests and field observations indicate that more attention should be given to the application of lath to exterior surfaces. Cracks frequently develop in stucco over laps or at junctions of metal and wire lath, indicating a weakness at these points. This may be due in part to reduced thickness of the stucco where the lath is lapped, or to insufficient tying and fastening at the joints. The ideal job of lathing would obviously be that in which the lath forms a uniform fabric over the structure, without seams or lines of weakness, and with equal reinforcing value in all directions. This ideal condition cannot be realized, but evidence is at hand to indicate that butted and laced, or well-tied horizontal joints are better than lapped joints, and in the case of ribbed lath, that carefully locked joints are better than lapped joints. Vertical joints must almost of necessity be lapped, but the joints may be made secure if they occur over supports and are well stapled at frequent intervals.

The use of wood lath as a base for cement stucco finds many advocates and many opponents, and more field and test data should be available before the evidence for and against wood lath can be carefully weighed. Further information is desired in regard to the type of wood lath best suited for cement stucco. In some of the most satisfactory work reported by the committee, the lath were of white pine 1 in. wide and ½ in. thick. Both material and size were here unusual, but the committee is of the opinion that this type of narrow lath is worthy of consideration. For want of information as to the practicability of specifying any particular kind of wood and unusual dimensions, no change is suggested at the present time. It may be stated, however, that nearly all of the test panels of wood lath erected at the Bureau of Standards developed large cracks, in such manner as to suggest that narrower lath (those used were 1⅜ in. wide) with wider keys and heavier nailing would have given better results. The tests also indicate that counter lathing in which the lath are applied lattice fashion produces no more satisfactory results than plain lathing. In view of the much greater cost of counter lathing the committee recommends that reference to this type of application be omitted from specifications.

More information is needed on the subject of insulation, particularly in connection with the back-plastered type of construction. At the present time, the warmth of the back-plastered stucco house in comparison with that of the sheathed house is questioned by some, but the available evidence seems to indicate that where insulation has been provided as specified, generally satisfactory results have been obtained.

Method of Determining Moisture Content of Wood

The Forest Products Laboratory, Madison, Wis., gives the following directions for determining the moisture content of wood:

1. Select a representative sample or disc of the material.
2. Immediately after sawing, remove all loose splinters and weigh the sample.
3. Put sample in a drying oven at 212° F. (100° C.) and dry until constant weight is attained.
4. Re-weigh the sample to obtain the oven dry weight.
5. Express the loss in weight as a percentage of the dry weight, thus:

$$\text{Percentage moisture} = \left(\frac{\begin{matrix}\text{original} & \text{oven-dry} \\ \text{weight} & \text{weight}\end{matrix}}{\text{oven-dry weight}} \right) 100$$

Short pieces of wood dry out much more rapidly than long ones. In order to reduce the time required for drying; therefore, the length of the sample in the direction of the grain should usually be about 1 in., or not more than to give the sample a volume of from 2 to 24 cu. in.

It is important that the weight be taken immediately after the sample is cut, for the material is subject to moisture changes on exposure to the air. The degree and rapidity of change are dependent on the moisture content of the piece and the air conditions to which it is exposed.

In order to insure good results, the weights should be correct to within at least ½ of 1 per cent.

When placed in the oven for drying, the samples should be open-piled to allow free access of air to each piece.

Fire Proof Brick and Tile Made from Sawdust

The editor recently examined some bricks and roofing tiles made from sawdust. One of the bricks had been exposed to the flame of an acetylene torch for several minutes, and was only slightly charred on the surface. Another had been alternately heated and frozen without injury. The bricks weigh only 62 lb. per cubic foot and have a crushing strength of 2,500 lb. per square inch.

In the manufacture of this new building material, sawdust is ground to a pulp, mixed with a special cement, pressed in a mold and allow to set for 8 hours, when it is ready for use. It is stated that the market price will be comparatively low. The material can be molded in any desired form, such as hollow tile, roofing tile, etc. It makes an excellent heat insulator for steam pipes, for refrigerators, etc. As a substitute for ordinary shingles it appears to have an especially good field, since it is almost as light as wood, yet is fireproof.

This new building material is manufactured by The Rolmer Co., 1424 Ewing street, Seattle, Wash.

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*The committee takes this opportunity of recommending fire stopping of frame structures as described in the National Board of Fire Underwriters' book entitled "Dwelling Houses."

Calculation of Wind Pressure on Arched Roofs

The reinforced concrete arch is an economical roof for large spans, over 32.8 ft. (10 meters). But to be economical, the reinforced concrete arch must be thin, both to economize in material and to avoid the use of heavy walls and columns for its support. In addition it should be remembered that the forces produced in a parabolic arch by the contraction of the concrete or by differences in temperature have the value

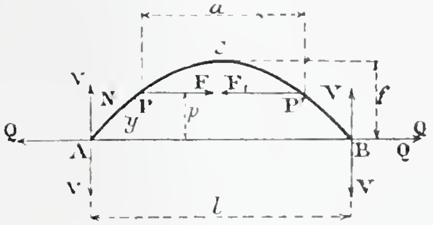

Fig. 1.

$45aEI\ 4f^2$; that is to say, are proportional to the moment of inertia I and that the bending moments at different points are also proportional to I or in other words, to the thickness of the arch. To determine the minimum thickness naturally requires careful and exact preliminary calculations. The following method of determining the forces and moments produced in parabolic fixed arches, is translated from an article by F. Grau in Le Genie Civil of May 31:

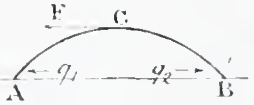

Fig. 2.

1st Case. Parabolic Arch Subjected to Two Forces F and F¹ Equal, but with Opposite Sign Applied at the Two Points P and P¹ with the Same Ordinate P. (Fig. 1.)—The force F applied at P gives to the support A and B two vertical reactions which are equal and opposite. The force F¹ applied at P¹ gives to A and B two equal reactions opposed to those of F. These reactions therefore balance each other. If Q is the horizontal force, M_0 the bending moment for conditions of equilibrium at A.

For any point N between A and P the moment is:

$$M = M_0 - Qy$$

For any point N between P and P¹:

$$M = M_0 - Qy + F(y - P)$$

For any point N between P¹ and B, the action of the two forces F and F¹, equal but with opposite sign, cancel each other, and:

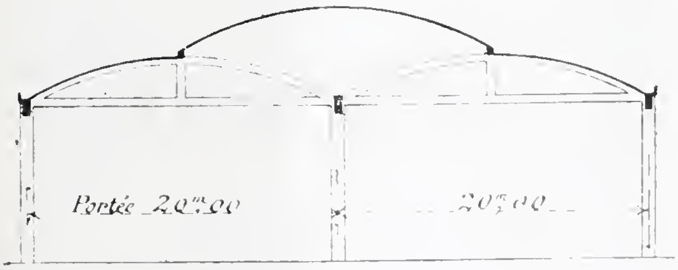

Fig. 3.

$$M = M_0 - Qy$$

Replacing M by these values in the general equations for an encastrés arch:

$$\int_0^l Mdx = 0 \quad \ldots\ldots [1]$$

and

$$\int_0^l Mydx = 0 \quad \ldots\ldots [2]$$

we have

$$M_0\int_0^l dx + F\int_P^{P^1}(y-p)\,dx - Q\int_0^l ydx = 0 \quad [3]$$

$$M_0\int_0^l ydx + F\int_P^{P^1}y(y-p)\,dx - Q\int_0^l y^2dx = 0 \quad [4]$$

Integrating, placing PP¹ equal to a and remembering that the equation of a parabola is:

$$y = 4f/l^2 \times (l - x) \quad \ldots\ldots\ldots\ldots [5]$$

we have

$$\int_0^l dx = l$$

$$\int_P^{P^1}(y-p)\,dx = \text{parabolic arch sector } PcP^1 = \frac{2a(f-p)}{3};$$

$$\int_0^l ydx = \text{parabolic arch sector } ACB = \frac{2fl}{3}$$

$$\int_0^l y^2dx = \int_0^l 16f^2x^2(l-x)^2dx/l^4$$

$$= \frac{16f^2}{l^2}\left(\frac{x^5}{5} - \frac{2lx^4}{4} + \frac{l^2x^3}{3}\right) = \frac{8f^2l}{15}$$

$$\int_P^{P^1} y(y-P)dx = \int_P^{P^1}(y-P)^2dx + P\int_P^{P^1}(y-P)dx.$$

and applying the preceding formulae

$$\int_P^{P^1} y(y-p)\,dx = \frac{8(f-P)^2a}{15} + P\,\frac{2(f-P)a}{3}$$

$$= \frac{2a(f-P)(4f+P)}{15}$$

Substituting these expressions in equations [3] and [4], we have:

$$M_0l + 2/3\ Fa(f - p) - Q \times 2/3fl = 0$$
$$M_0 \times 2fl/3 + 2a(f-p)(4f+p)/15\ F - 8f^2l/15\ Q = 0$$

Eliminating M_0 from the two equations we find:

$$Q = a(f-P)(2f+3P)/2f^2l \times F \quad \ldots\ldots [6]$$

2d Case. The Parabolic Arch Is Subjected to a single Horizontal Force Applied at One Point P. (Fig. 2.)—Let q_1 and q_2 be the horizontal forces produced at A and B by this force.

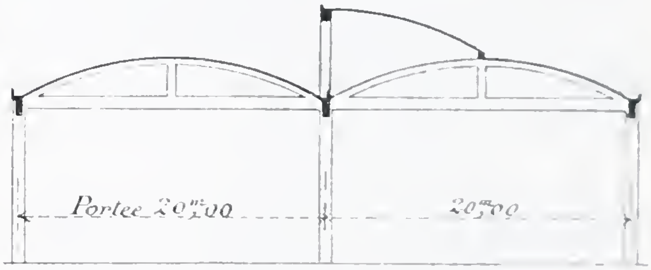

Fig. 4.

The equation of (projections) gives:

$$q_1 + q_2 = F$$

If we imagine a force F, equal and opposite to the first, applied at the point P¹, located systematically with P, this new force will produce at A, a horizontal force 9, and at B a horizontal force q_1.

The total force at A will therefore be:

$$q_1 - q_2 = Q$$

From these two equations, we obtain:

$$q_1 = F + Q/2 = F\ 2f^2l + a(f-p)(2f+3p)/4f^2l \quad \ldots [7]$$
$$q_2 = F - Q/2 = F\ 2f^2l - a(f-p)(2f+3p)/4f^2l \quad \ldots [8]$$

3d Case. The Parabolic Arch Is Subjected to a Uniform Horizontal Pressure Acting Against Half of the Arch (Wind).—Let m be the unit pressure. On a very small element of the arch, of ordinate p, the pressure will be:

$$dF = m\,dp$$

giving at A a force:

$$dq_1 = m\,dp \times 2f^2l + a(f-p)(2f+3p)/4f^2l \quad [9]$$

From equation [5] of the parabola, we obtain:

$$P = 4f/l^2 \times l - a/2 \times l + a/2 = f(l^2 - a^2)/l^2$$
$$dp = 2af/l^2\ da$$

Substituting these values for P and dP in equation [9] and integrating, we find:

$$q_1 = 11/14\ mf$$
$$q_2 = 3/14\ mf$$

Vertical pressure and bending moment M_1 at A and M_2 at B, for all points of the left half of the arch:

$$M = M_1(l-x)/l + M_2x/l - q_1y + my^2/2 + Vx$$

For all points of the right half of the arch:

$$M = M_1(l-x)/l + M_2x/l - q_1y + my^2/2 - m\frac{(f-y)^2}{2} - Vx$$

Substituting in the equations:

$$\int_0^l Mdx = 0 \text{ and } \int_0^l Mxdx = 0$$

and integrating, we obtain:

$$20(M_1 + M_2 - Vl) - 40fq_1 + 13mf^2 = 0 \quad \ldots [10]$$
$$40M_1 + 80M_2 + 80Vl - 80fq_1 + 21mf^2 = 0 \quad \ldots [11]$$

If the forces on the right are used instead of those on the left, the moment of any point in the right half of the arch is:

$$M = M_2 l - x/l + M_1 x/l + q_2 y - Vx$$

and for the left half of the arch:

$$M = M_2 l - x/l + M_1 x/l + q_2 y - Vx + m/2\,(f - y)^2$$

Substituting these values for M in the equation:

$$\int_0^l M dx = 0$$

and integrating, we obtain

$$30(M_1 + M_2 - Vl) + 40fq_2 + 3mf^2 = 0 \quad \ldots\ldots\ldots\ldots [12]$$

Replacing q_1 and q_2 by their values 11mf/14 and 3mf/14, the three equations [10], [11] and [12] become:

$$M_1 = -19Pf^2/280,\ M_2 = 51mf^2/280,\ V = mf^2/21$$

Moment at any point with co-ordinates x and y. The moment of a point in the left half of the arch is:

$$M = M_1 l - x/l + M_2 x/l + Vx - 9_1 y + my^2/2$$

and for the right half of the arch:

$$M = M_1 l - x/l + M_2 x/l + Vx - 9_1 y + my^2/2 - m(f - y)^2/2$$

Substituting for M_1, M_2, V and y their values as found above we obtain for the left half of the arch:

$$M = pf^2/280l^4\ (2240x^4 - 4480lx^3 - 3120lx^2 - 810l^3 \times 51l^4)$$

and for the right half of the arch:

$$M = p^{f2}/280l^4\ (-240x^2 + 310lx - 89l^2)$$

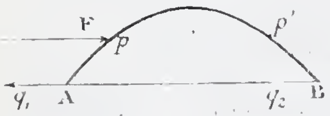

Fig. 5.

Arches Subjected to a Single Horizontal Force.—This case is found in certain forms which consist of a principal arch with a more elevated part for illumination, etc. (Figs. 3 and 4.) This higher part produces a horizontal force which acts at one point on the lower arch.

The forces 9_1 9_2 being given by equations [7] and [8], the moments at the supports and the vertical loads on the supports may be computed, as is done above, by the equations:

$$\int_0^l M dx = 0 \text{ and } \int_0^l M x dx = 0$$

These quantities being known, the moment at any point is determined as before.

In particular if the load F is applied at the middle (Fig. 5) of the arch, we have:

$$q_1 = q_2 F/2,\ M_1 = Ff/8,\ M_2 = Ff/8,\ V = Ff/l$$

The moment at any point with an abcissa x will be, for the left half of the arch:

$$M = M_1 l - x/l + M_2 x/l + Vx - Qy = Ff/8l^2\,(l^2 - 10lx + 16x^2)$$

and for the right half of the arch:

$$M = Ff/8l^2\ (-7l^2 \times 22lx - 16x^2)$$

Securing Smooth and Uniform Surface Finish for Concrete Bridges

One of the special features of the recently completed Bellevue Park Bridge at St. Louis is the excellent appearance of the concrete surface. This finish was secured in the following manner: As soon as the forms were removed such portions of the concrete surface as appeared to be porous were covered with a thin coating of mortar, consisting of 1 part portland cement and 2 parts Pacific white sand, applied with a brush and thoroughly rubbed in with carborundum blocks and allowed to stand for two days. The entire surface of the concrete was then wetted and rubbed with caroborundum blocks until all form marks were removed. A coat of mortar mixed as above noted was then applied over the entire surface, rubbed in thoroughly with the carborundum blocks, brushed off smooth and allowed to harden for two days. Finally the entire surface was again wetted and rubbed and then washed with clear water. The white sand was a very fine silica sand that acted well in grinding the surface and seemed to enter into and fill up the pores in the concrete. There was a total of 20,500 sq. ft. of surface finish work on the bridge. This was paid for at a unit price of 3¾ ct. per square foot.

A. A. E. to Move Its Head Offices.—The American Association of Engineers has grown so fast during the last six months that the national headquarters of the association in Chicago has outgrown its quarters. Within the next two or three weeks these headquarters will be moved from the present location at 29 South La Salle street to the Nepeenauk Building at 63 East Adams street, where a lease has been taken on 6,000 square feet of office space. The Chicago Chapter, which has over 1,100 members, will take over the space vacated by the national headquarters of the association.

Design and Construction Features of Concrete Fuel Oil Tanks*

By H. B. ANDREWS,

Consulting Engineer, Springfield, Mass.

The reservoir should be located a safe distance from inflammable structures as far as possible consistent with pumping requirements. If near buildings it should be covered with at least 18 in. of earth, to decrease fire hazards and also to minimize oil evaporation. If distant from buildings, it should be at least half underground, and, if possible, the excavated material should be used in banking up around it.

The reservoir should be limited in size for two reasons: First, the necessity for not exceeding a day's working limit in operation of pouring concrete so that joints between operations may be eliminated, and second, so that in case of an accident or fire in any reservoir too much oil in storage will not be involved. This size limit should not be over 300,000 gal. under most conditions.

Reservoirs should be circular in shape, the better and more directly to take care of involved stresses and to avert danger of tensile or temperature cracks. They should be so proportioned and designed as to limit the number of pouring operations of concrete, in order to avoid joints between these operations.

Care should be taken to provide for all exterior stresses, such as hydrostatic pressure from groundwater, earth pressure on walls, and roof if reservoir is buried, and also to avoid as far as possible concentration of loads on walls or footings. Where joints are absolutely necessary they should be so protected that there will be no leakage through them. Regarding hydrostatic pressure, while engineers have found from tests that this pressure in soils is only about 50 per cent of the full head of water, it is not safe to design for stresses less than the full head, as any deflection in the concrete admitting a film of water betwen the earth and the concrete will produce the full hydrostatic pressure.

Concrete surfaces must be temporarily or permanently proteced so that oil will not come in immediate contact with them if the concrete is less than six weeks old.

Falsework must be designed to hold concrete temporarily in place so that it will not fail or be distorted while placing concrete. It is especially necessary to provide for the firm holding of wall forms, as the pressure of several feet of concrete poured quickly as a monolith is intense, and any "give" of the forms after the concrete has obtained its initial set breaks up the crystals already formed and allows expansion of the concrete mass, with resultant porosity and loss of strength.

Concrete must be so designed that it will resist all exterior stresses to which it is subjected and so that it will be oilproof. One of the principal features of this design is to make the walls of circular reservoirs in tension sufficiently thick so that the ultimate strength of the concrete in tension will not be exceeded. It is not meant to leave out the steel reinforcement so that the stress will theoreticaly be borne by the concrete, but nevertheless it will be borne by it unless some unforeseen weakening of the concrete should throw it upon the steel.

An extended investigation, by the writer, on high circular concrete standpipes for water showed that if the concrete in the wall was stressed beyond its elastic limit, or ultimate strength, vertical hair cracks will appear of sufficient width to admit water into the body of the concrete. This ultimate tensile strength in a 1:1½:3 concrete from tests made for the writer at the Watertown Arsenal was 203 lb. per square inch. Where the concrete is in large sectional areas, and reinforced, this tensile strength will probably be somewhat higher. If a stress not exceeding 150 lb. per square inch is allowed in tension there will be no danger of these vertical cracks appearing.

Reinforcement must be so designed that it will take care of all interior and exterior stresses, and with fittings to hold it rigidly in place while the concrete is being poured. Steel in tension in walls should not be stressed over 10,000 lb. per square inch to conform with insurance company requirements. The writer does not think that it is necessary to figure the stress as low as this, under usual conditions, as he has satisfactorily constructed many reservoirs using a stress of 14,000 lb. But the lower stress is an additional safeguard against inferior workmanship by inexperienced contractors and against any decrease in bond strength due to oil penetration of concrete. It is probably unwise to depart radically from insurance company recommendations. All reinforcing rods in concrete exposed to oil should be of a deformed section, for better bonding value.

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*From a paper presented at the annual convention of the American Concrete Institute, June, 1919.

For other parts of the reservoir the recommendations of the Joint Committee on Concrete and Reinforced Concrete should be followed.

The concrete should be no leaner than a mix composed of one part of cement, 1½ parts of sand and 3 parts broken stone or gravel. To this mix should be added a "densifier." Hydrated lime has been found economical and satisfactory for this purpose, using 10 lb. of dry lime to each bag of cement. The stone must be hard and clean, the best material being traprock, granite or gravel. The sand must be free from any deleterious matter, and should be well graded. Cement should be of an established quality.

The concrete should be deposited continuously in concentric layers not over 12 in. deep in any one place. No break in time over 30 minutes is permissible in depositing concrete during any one operation, and if any delay occurs amounting to 30 minutes or more the previous surface must be thoroughly chopped up with spades before the next layer of concrete is deposited.

The different operations in pouring are: (1) The Pouring of the floor and footings; (2) the pouring of the entire wall; (3) the pouring of the roof. In small reservoirs the wall forms may be supported so that the footings, floor and wall may be poured in one continuous operation. An approved joint or dam must be made between the floor and the wall.

Concrete should be mixed by a mixing plant of sufficient size and power to carry out each separate prearranged operation without danger of delay during the process. The materials should be mixed at least 2 minutes in the mixer, using just enough water to obtain a plastic mix without excess water coming to the surface after the concrete is deposited, and a measuring tank should be used so that the amount of water may be kept uniform.

The concrete when deposited in forms should be well spaded by at least four competent laborers who are not afraid to use their muscle in compacting the concrete thoroughly and working out the trapped air bubbles.

Reinforcement should be of round deformed medium steel bars. These bars should be bent or curved true to templets carefully placed in their predesigned location, and rigidly maintained there by mechanical means. No laps should be less than 40 diameters and no two laps of adjacent rods should be directly opposite each other.

The forms should be of a good material, strongly made and so braced, or held in place by circumferential bands, that no distortion allowing displacement of concrete during its initial set is possible.

The surface of the floor should be troweled smooth as soon as it can be properly done.

Concrete designed and placed as recommended herein is practically oil-tight, but as oils are somewhat detrimental to fresh concrete it is advisable to put on an interior wash or coating to protect the fresh concrete from the action of the oil, for such a time as may be necessary for it to cure and harden sufficiently. Silicate of soda, while not a permanent coating, has been used satisfactorily for this purpose according to the following specification for oil-proofing:

The surface of the floor and the interior surface of the wall are to be coated with silicate of soda of a consistency of 40° B., and applied as follows:

First Coat—One part of silicate of soda and three parts water, applied with brush, and all excess liquid wiped off with cloth before drying.

Second Coat—One part of silicate of soda and two parts water applied as above.

Third Coat—One part silicate of soda and one part water, applied with brush and allowed to dry.

Fourth Coat—Applied same as third.

Strength and Other Properties of Wire Rope

There have been few systematic researches conducted by engineering laboratories to determine the physical properties of wire ropes. The tests which have been made by manufacturers are, as a rule, not available for critical comparative study by engineers. The investigations which have been made abroad, notably those by Tetmajer and the South African Commission, have covered particular types of constructions, such as cables for tramway and mine hoists. The results cannot be strictly applied to American practice. The reason that systematic experimentation in this field has been somewhat limited may be attributed to the fact that it is difficult to obtain a large number of specimens for test purposes which have been selected under uniform specifications. The relative cost of preparing specimens is, moreover, as a rule, quite out of proportion to the yield of test data. In Technologic Paper No. 121 issued last month by the U. S. Bureau of Standards results of tests made by the Bureau upon 275 wire rope specimens are given. The specimens selected under the specifications of the Isthmian Canal Commission, and ranged in diameter from ¼ in. to 3½ in. and comprised five of the more common classes used in engineering practice. The laws of construction of the specimens were determined and were used as the basis of the analysis of their physical behaviors under stress. Numerous comparative physical and chemical tests were presented of the wires fibers and lubricants used in wire rope construction. Over half the specimens were plow and crucible-cast steel hoisting rope of 6 and 8 strands of 19 wires each. The remainder were guy and tiller ropes of 6 strands of 7 wires and 6 strands of 42 wires each.

The conclusions, as given in the paper, are as follows:

Recapitulation of Structural Data. The linear dimensions of the wires, strands, and rope cores were found from measurements to be proportional to the diameters of the cables. The diameters of strands and rope cores were generally one third the diameters of the cable, the cores of the 8 by 19 plow-steel rope being slightly larger. The mean pitch or lay of a strand was approximately 7½ times the diameter of the cable. The mean lay of the wires was approximately 2¾ times the diameter of the cable. The mean diameters of the wires are given approximately by the equation

d = diameter of wires; D = diameter of cable;
N = number of wires in outer ring of strand

$$d = K\frac{D}{N+3}; \qquad K = \begin{cases} 1.0 \text{ for hoisting and guy rope} \\ .8 \text{ for flexible hoisting rope.} \\ .33 \text{ for tiller rope.} \end{cases}$$

The mean aggregate sectional area of the wires in a cable in terms of its diameter is given approximately by the formula:

$$A = C\,D^2; \quad C = \begin{cases} 0.41 \text{ for 6 by 19 plow-steel rope.} \\ .38 \text{ for 6 by 19 crucible-cast steel rope} \\ .38 \text{ for 6 by 7 guy rope.} \\ .35 \text{ for 8 by 19 plow-steel rope} \\ .26 \text{ for 6 by 42 iron tiller rope} \end{cases}$$

The sectional area of the steel in a cable in terms of the mean area of its wires is given by the formula:

$$A = S[3n(n-1)+1]a; \quad \begin{cases} A = \text{area of steel.} \\ S = \text{number of strands.} \\ n = \text{number of concentric rings} \\ a = \text{mean area of a wire} \end{cases}$$

Recapitulation of the Results of Tests of Cables.—It was found when the observed maximum loads were platted as functions of the diameters of the cables of each class that the lower boundary of the field comprising these observations could be expressed within fairly close limits by the formula

$$\text{Load} = C\,75000\,D^2$$

D = diameter of cable,

$$C \begin{cases} = 0.9 \text{ to } 1.1; \text{ mean about } 1.0. \text{ — Plow steel 6 by 19 cables.} \\ = .8 \text{ to } 1.00; \text{ mean about } .85. \text{ — } \begin{cases} \text{Plow steel 8 by 19} \\ \text{Crucible-cast steel 6 by 19} \end{cases} \\ = .3 \text{ to } .45; \text{ mean about } .35, \begin{cases} \text{Tiller rope 6 by 42} \\ \text{Guy rope 6 by 7.} \end{cases} \end{cases}$$

The specifications and the standard strengths of the manufacturers' were found in general to agree quite closely with the loads defined by these lower boundaries. The arithmetical means of the observed maximum loads from the tests were usually about 5 to 12 per cent higher than the minimum values recorded, depending upon the particular grade of steel used by the manufacturer in meeting the requirements of the specifications.

The mean values of the observed maximum stresses found for the different classes of cables when platted in curves showed a general correspondence with similar curves platted from stresses figured from the maximum loads given by the specifications and the standard strengths of the manufacturers. The smooth curves following the general trend of the platted observations were of the type found in tests of wires of different diameters. The relatively high maximum stresses found for small cables were attributed to the greater strengths of the wires as a result of wire drawing.

The observed unit elongations under cumulative stresses showed some irregularities for different cables of the same class and diameter. The elongations were nearly proportional to the stresses in a particular cable. The calculated moduli of the cables varied from 3 by 10^6 to 9 by 10^6 lb. per square inch of cable section. While this is increased by service, it is believed the limit of 12,000,000 lb. per square inch used in the calculation of bending stresses is ample.

Recapitulation of Results of Tests for Quality of Material.—The tensile strengths of wires in a strand were quite uniform. The maximum elongations were relatively high, considering the strength of the wires. The strengths of wires in cables of the same class and diameter were quite uniform when the steel was of the same grade. The relatively large departures from the mean in a group of cables of the same class may be attributed to the fact that the chemical constituents are not identical in all cases, but depend upon the particular type of steel submitted by the manufacturers in meeting the provisions of the specifications. The variations in the strengths of the cables were larger than would have occurred if all specimens of a class had been selected from the same manufacturer and had they been constructed of the same grade of steel.

The fiber used for rope cores in the hoisting cable of 1¼ and 1½ in. diameter was estimated to be manila, jute, or istle. In some cases mauritius had been mixed with the istle. Manila fiber is considered to be most efficient for power transmission and hoisting cables, on account of its greater strength and ability to resist alternate bending. It is probably more efficient for ship rigging and like purposes, where the cables are exposed to sea water.

The preservative and lubricants used were wood or vegetable tar combined with petroleum oil or other petroleum products. Experience from tests of cable used in practice shows that the cables when bent over sheaves should be lubricated at frequent intervals to prevent corrosion of the wires and rigidity and drying out of the core, and to insure more freedom of action of the strands and wires in adjusting themselves in resisting direct and bending stresses. Otherwise the strength is impaired by corrosion and denting of the wires from irregular stress distributions.

The efficiency of a cable in developing the strength of the wires depends theoretically upon the construction and lays of the strands and wires. The effective component along the cable axis was found to be about 89 per cent of the working stress in the wires for 6 by 19 plow-steel cables. The mean component developed at rupture was found to be about 8 per cent less than the theoretical value computed on the basis of an elastic behavior of the material. This was attributed to different degrees of ductility possessed by the wires and some variation in their strengths. It is the opinion that the efficiency of different constructions will be in closer agreement with the computed efficiency when working stresses are not exceeded.

Heavy Girder Spans for Railway Bridges.—Long heavy through girder spans were used in the reconstruction of the Big Four Ry. bridges over the Scioto River and Olentangy Creek near Columbus, O. The Scioto River bridge has one span of 106 ft. 3 in., and three of 95 ft. 9 in. The other bridge has three 109 ft. 3 in. spans. The bridges were designed for E-70 loading, New York Central Lines specifications. Thus, with a double track, through-girder span, 106 ft. long, the construction became very heavy, as will be seen from the fact that the steel in the one span weighed 250 tons.

The Contractor's Salary as an Overhead Charge*

By J. F. LIDRAL,

Of Arvesen & Lidral, General Contractors, Seattle, Wash.

There are many among you who have been brought up on construction work since boyhood. There are others among you who have perhaps gone to school to more scientifically equip yourselves for your life's work. In either case you have devoted long years of experience and hard work to place yourselves in a position to be able to accomplish something which the ordinary individual cannot do. You have all the marks of a profession if you will demand from the world that you are professional men.

When a calling is placed in the rank of a profession, the world recognizes that the individual engaged therein has been qualified by virtue of long study and experience and classes him as an expert who is capable of understanding and undertaking difficult problems. With this recognition comes also the inclination to be willing to compensate him in direct proportion and to the extent that he is able to save time and money for the man who engages him.

You have endeavored to build up your organization and working force. You have saved your money and paid your bills in an attempt to build up your credit standing. Why? So that you are able to perform work better and quicker and buy material cheaper than the outsider or the ordinary layman.

Now, laying aside for the moment the fact that you risk your money and reputation in your business, how much in the nature of a salary are you worth to your firm? Are you working simply for the love of work or are you worth a salary of $100, $200 or $1,000? You hire a foreman and you pay him perhaps $10 a day or approximately $250 a month. This foreman is working for you because he lacks something you possess. Either he does not possess the necessary knowledge to run his own business or his credit is gone or he possesses too much knowledge, knowing that he would be minus his $250 if he figured his worth as do some contractors. The foreman works his 8 hours per day and his troubles end.

There are very few of you who limit our week's work to a minimum of 40 hours for your profession. It is more likely that you are on the job at 7:30 and spend the time until 4:30 racing like mad to keep it going. Then you go to the office until 6 trying to catch up with what you missed during the day. In the evening you have an engagement, here, for example, if you wish, or some party wishes a little free information about a building they never intend to erect, or your car needs adjusting after a hard day's abuse hauling nails and wheelbarrows or you may go back to the office to work on the books to worry about how you are coming out on that job you took too low. Even Saturdays and Sundays are not exempt for most of you, and I'll wager that the majority of you neglect your families almost entirely. It is safe to assume that you put in more than double the time your foreman does. Is it not logical that each and every one of you is worth at least $500 to your firm? This item is just as much an overhead as is your office rent, interest on the money invested and other items. In other words to the overhead of every firm should be added a salary for each individual engaged therein.

Some of you may not agree with me perhaps and will make the declaration that a man's compensation should come out of the profit. The definition of business is an undertaking to which risk is attached and which is attempted in order to result in a profit. Your overhead does not and cannot include a probable loss on any job. You lose money as all of you have done at different times. Your profit then is solely the necessary compensation over and above everything else to warrant your assuming the risk involved. In other words it is a bonus over and above your overhead and labor which is rightfully yours for the assumption of the undertaking.

It may be well at this point to make comment on some of the work going on this spring. There is at present a noticeable shortage of carpenters and bricklayers. All are employed, indicating that there is considerable work underway. Go along any street of this city and you will see evidence of considerable building activity. How many of you contractors have a job at present that you are satisfied is bringing you all the returns to which you are entitled. There seems to be plenty, and still most of you are marking time waiting for more work to turn up at better prices.

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*Abstract of an address presented July 1 before Seattle Master Builders' Association.

We will take a concrete example: The 1-story mill type garages, so many of which are under construction at the present time, with brick walls, concrete floor, tar and gravel roof on trusses and cold water paint on the interior. This is the simplest sort of a job to figure and yet our figures vary 100 per cent. Why? There are no slave drivers among us nowadays. The workmen will give just about the same amount of work to all of us. Your credit, let us assume is equally good or at most we cannot underbuy each other more than 10 per cent. There are two reasons. First, you are afraid that the other fellow is going to grab it and you cannot get over the idea that you may make a little spending money if all goes well and you are lucky. Second, you have been influenced by owners and real estate operators who convince you that such buildings have always been and are now being built for 6½ cts. a cubic foot. It can't be done. You can't put in brickwork for much less than $40 and 8-in. concrete, including form work, much under $18, so what is the use and why worry about the cheap owners and architects who convince some uninformed mortal to pack their troubles. I plead with you that in these days of plenty for all of us that you figure to come out on top, allowing for your overhead, a salary for yourself and a fair profit.

In closing, I would like to ask each one of you this question: What do you consider you are worth to the business and professional world standing apart as one who is an expert? Not until you take enough personal pride in yourself and place a fair price on your labor will the world wake up to the fact that you deserve recognition as an expert and are entitled to a fair compensation for the time, money, experience, and energy which you have devoted to your life's work.

Waterproof Glues in Automobile Manufacture

Some of the new waterproof glues developed primarily for aircraft purposes during the war offer the possibility of overcoming a difficulty that has proved very annoying, both to the automobile owner and to the manufacturer, wherever linoleum is used on the running boards or as a covering for the floor of the car. Ordinary glues which are soluble in water are not very effective in cementing linoleum, and most automobile owners have soon discovered that the glue disintegrates and the linoleum comes loose after the car has been washed a few times. Casein glues are admirably adapted to this purpose, and if the quality is right and they are properly applied the linoleum should give no trouble during the life of the car. Casein glues are exceedingly resistant to the action of water and retain a very high percentage of their original strength, even after long immersion under water They are comparatively inexpensive, and the materials from which they are made are readily available in the market. They are applied cold and will set without the application of heat.

Civil Service Examination for Bridge Engineer. The U. S. Civil Service Commission will hold an open competitive examination for junior highway bridge engineer on Sept. 17. Vacancies in the Office of Public Roads and Rural Engineering, Department of Agriculture, at $1,200 to $1,600 a year, and in positions requiring similar qualifications, at these or higher or lower salaries, will be filled from this examination. In addition to the entrance salary, appointees whose services are satisfactory may be allowed the temporary increase granted by Congress of $240 a year. The duties of appointees will consist of making surveys of bridge sites, the design and preparation of plans for highway bridges, the superintendence of their construction, and their inspection.

Standardization of Structural Steel in Australia.—A conference which had for its object the standardization in Australia of structural steel sections has just concluded its work at Melbourne. The object of the conference was to bring about changes in the sections to meet the conditions of manufacture in Australia, and also to endeavor to agree upon a reduction in the number of steel parts that users in Australia would demand from makers and thereby reduce the cost by eliminating those for which there is little demand. It is stated that as a result of the conference a series of structural shapes has been defined which will enable Australian manufacturers to meet practically the whole requirements of the commonwealth. A certain number of sections is to be allocated to each steel rolling mill, which it will manufacture exclusively, and thus be insured a quick turnover on its outlay and, on the other hand, users will have at their disposal a constant supply of standard sections.

Co-operation Between Engineers Architects and Construction Men

Closer co-operation between architects, engineers and contractors was waged in the report of the Post-War Committee on Architectural Practice, submitted at the recent annual convention of the American Institute of Architects. The following is extracted from the report

Should there not be a closer co-operation between engineers, architects, and construction men? Should not all these qualities be integrated within the architect's organization? Should not all be present at each stage of the procedure? Does this point toward larger organizations in which men of varying qualifications co-operate figuratively as equals rather than the present plan whereby one man—the architect employs others to work under his direction? Does it not suggest the organization of the architect's own office on lines which would insure the interest of every assistant as a creator rather than as a wage-earner.

Great changes have taken place, in recent years, in the status of the contractor in relation to building enterprises. In important work the contractor now, generally, sells his services on a professional basis. His remuneration is understood to be for the use of his organization and its knowledge of the building business. In such cases this changes the relation of the architect to the whole building procedure.

Many contractors have been quick to realize changed conditions and the apparent desire of modern business to deal with one organization equipped to handle all phases of a building problem. There are, to be sure, some so-called "general contractors" who do nothing but trade on a name, have no technical knowledge of building, and live on the skill and credit of their sub-contractors. But there are also general contractors and construction companies composed of able men, which employ able designers and do all work from the making of drawings and specifications to the financing, building and furnishing of the structure As against such a system, the average architectural organization dwindles in impressiveness. The services of an architect, where a really competent contractor is selected on the basis of "confidence," is not required in the same degree as in the older method, to watch the performance of the contractor or to safeguard the expenditures of the owner. Nor is he so frequently called upon to adjudicate disputes that may arise between the owner and the contractor over interpretations of the contract obligations. On the other hand, where the old form of lump sum contract is carried out with incompetent so-called general contractors who sub-let everything and know nothing of building, the work and responsibility of the architect is greatly increased. On the whole contractors are more and more unwilling to guarantee costs as the complexities and uncertainties of building increase and there appears to be a shifting relationship in the professional responsibilities of architect and builder.

In view of these tendencies shall we not have to revise the established relations of architect and contractor? Do these not also suggest a vital reason for establishing a closer co-operation and understanding between architects, consulting specialists, and contractors, and indicate a community of interest that has hitherto been unapparent? Must not the architect encourage and utilize every available outside aid to efficiency and yet clarify his own function as an element in building production? Can the man who creates the design also be the director or manager of the whole procedure of building or shall he be primarily the designer? Should not the architect by his experience and training be the best fitted to co-ordinate all branches of the work and successfully administer the enterprise? If not, does it not suggest a serious defect in his training? Would not the contractors welcome such administration if applied in a business-like way by the logical interpreter of the design? Have not building and architecture (which once were the same art) drifted too far apart?

High Prices of Building Construction to Continue

The Committee on Housing of the Merchants' Association of New York in a report made public recently states that construction of houses is being delayed by two things:

1. Lack of money for building operations caused by, (a) insufficient return on mortgages due to federal taxes; (b) insufficient return on operation of building and the apparent hostility of the public to the collection by the owner of a sufficient return.

2. Doubt as to the continuance of the prevailing high prices of building construction and reluctance to build now while they still prevail.

The rapidity with which the situation improves will depend directly upon the extent to which these two adverse factors are eliminated. It has appeared to the committee that the lack of money for building operations is by far the most serious hindrance to construction. Real profiteering should be stopped if possible, but the menace of preventing profiteering by public investigation accompanied by publicity brings the honest landlord into disrepute. Many may be deterred from constructing houses and financing the equity by fear that public opinion will not allow the landlord a fair and reasonable return on his invested capital.

Next to the scarcity of money available for building construction, the committee believes that doubt as to the continuance of the prevailing prices of building construction is the chief detriment to immediate activity in building. It is the unanimous opinion of the committee that building construction prices will not decrease to any material extent for an intermediate period of years. Inasmuch as the increase of prices and monetary inflation has taken place in practically every civilized part of the world, there is no reason why the adjustment of prices should be one toward the prices existing in 1914. On the contrary, this adjustment will be a process of rearranging prices on the basis of the new price level.

A study of price conditions in other important countries shows that the increase of prices in this country has been less than in most countries. Therefore, prices here are doubtless nearer the new general price level than is the case elsewhere. A great deal has been said about price conditions in the period immediately following the close of the Civil War. The situation then and now are not directly comparable, and that therefore while the Civil War experience is probably indicative of the immediate future, it is not necessarily so. The effects of the Civil War were confined largely to North America, rather than to the entire world. The destruction and hence reconstruction was confined to comparatively small agricultural areas instead of to large industrial sections and entire countries.

Shrinkage in So-Called "Compression Wood"

"Compression wood" is a term applied to wood of an abnormal growth, which is considerably heavier than normal wood and is usually further distinguished by very wide annual growth rings, a lack of contrast between the spring and summer wood, and a relatively dark color. How this abnormal growth is caused is not definitely known, although the theory has been advanced that excessive leaning of the tree during growth produces it, the "compression wood" being formed on the lower or leaning side.

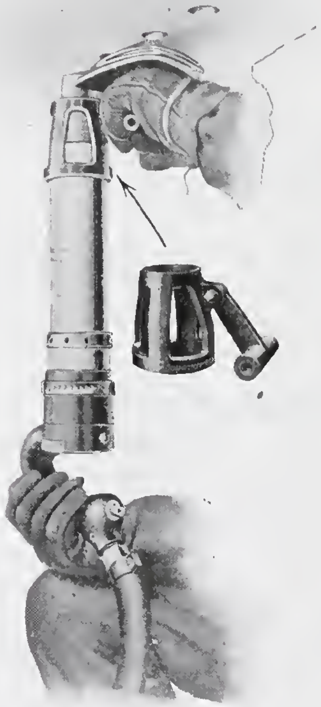
A structural timber containing "compression wood" was recently received for examination at the Forest Products Laboratory, Madison, Wis. The timber had failed in tension in the "compression wood." Large cross breaks had opened up across the grain and rendered this portion of the timber useless in withstanding further stresses. The "compression wood" was very brash and exhibited low strength in mechanical tests, except in compression parallel to the grain, in which it was about equal to the normal wood. Its specific gravity was considerably greater than that of the normal material.

The chief difference between the normal and abnormal wood, however, was in the matter of shrinkage. The "compression wood" was found to have a longitudinal or end shrinkage six times as large, and radial and tangential shrinkages less than half as large as those of the adjacent normal wood.

In the beam examined, the tendency of the "compression wood" toward excessive shrinkage had been resisted by the normal wood, with the result that the "compression wood" was actually pulled in two.

Hand Grip for Pneumatic Riveting Hammers

A new device for pneumatic riveting hammers designed to give the riveter a firm full hand control of the hammer without grasping the heating cylinder is illustrated below. It is claimed for this device that it combines an ideal hammer grip and an absolutely safe set retainer; that it allows the riveter to get back of the hammer with the full weight of the body, without having to "strong arm" the work; that it insures perfect control of the hammer and an unobstructed view of the work at all working angles; and that it allows the workman to work over hot rivets without burning his hands and eliminates the possibility of jammed or squeezed fingers. This device is known as the Boyergrip. It is manufactured by the Chicago Pneumatic Tool Co., Chicago.



The Boyergrip.

Long Span Concrete Roof Arches

Several examples of long span concrete construction are noted in a recent issue of Concrete in Architecture and Enginering. These inclue a 50 ft. roof arch used in the Anderson Garage at Salt Lake City and a 70 ft. arch span in the foundry building of the Garfield Smelting Co. at Garfield, Utah. The roof supports of the garage were designed as rigid frames. Advantage is thus taken of the greatly reduced moment at the center of the span by virtue of the fixity of the arched girders at the column tops. This, of course, introduces bending moments not only in the girders but in the columns as well. The same general type of roof construction was used for the foundry building, excepting that in the latter there are two columns instead of three as in the garage.

In constructing the bents of the foundry building, the forms for both the legs and arched girders were assembled on the ground and hoisted into place with a stiff-leg derrick, the reinforcing being all in place before hoisting. The same forms were used eight times, thus obtaining low cost and enabling the work to proceed without interruption or obstruction of the work rising from assembling forms in place.

Resolutions of United Engineering Society on Death of Andrew Carnegie

Andrew Carnegie's death, Aug. 11, 1919, at Lenox, Mass., brought to its close a career which greatly advanced all the engineering arts and sciences. By the introduction into the United States of the Bessemer process for the production of steel and by the establishment and development of steel plants, which became the greatest in the world, he made available for engineers the most useful modern material for engineering construction. In the successful conduct of many industrial enterprises, he amassed great wealth, the possession of which he came to regard with deep seriousness as a public trusteeship. He devoted himself to the distribution of large portions of his fortune to projects for the benefit of mankind. He distributed his wealth not only in many directions, but also with the exercise of great wisdom based on careful investigation. His munificence provided large funds for the building of a home for the great national engineering societies and many associate societies. He was an honorary member of the American Institute of Mining and Metallurgical Engineers and American Society of Mechanical Engineers. He was personally known and loved by many engineers. In view of these facts, be it

Resolved, That the American Societies of Civil, Mining, Metallurgical, Mechanical and Electrical Engineers, the United Engineering Society and the Engineers' Club, herein express to the family of Mr. Carnegie and record their sincere appreciation of the great contributions of Andrew Carnegie to the advancement of engineering, and of his friendly assistance in making possible beautiful homes for the Engineering Societies and the Engineers' Club, thus fostering the spirit of unity in the profession.

Effect of Age on Casein Glues

That casein glues can be successfully used any time after mixing up to the time they become unworkable is the conclusion drawn from a number of tests at the Forest Products Laboratory. Ordinarily, casein glues exhibit a life of from 3 to 5 hours, though there are some which remain useable over a much longer period. The laboratory has from time to time received inquiries as to whether or not these glues could be relied upon to give as satisfactory strength and water resistance after three or more hours as they do immediately after mixing.

To study this question, shear blocks and plywood panels were made up hourly starting at the time the glue was mixed and continuing until the glue became so thick that it was unworkable. The blocks were allowed to season for 7 days and were then tested in shear in the usual manner; the panels were given shear tests, 8-hour boiling tests, and 10-day soaking tests. Results of the tests on one commercial glue are shown in Tables I and II. These are typical of the results obtained with other glues.

TABLE I—RESULTS OF JOINT STRENGTH TESTS.

Age of glue in hours.	Average shearing strength in lbs. sq. in.	Percentage of wood surface in failure.
½	2,170	24
1½	2,137	51
2½	2,276	58
3½	2,453	3
5	2,098	23

TABLE II—RESULTS OF PLYWOOD WATER RESISTANCE AND STRENGTH TESTS.

Age of glue in hours.	Condition after boiling 8 hours.	Condition after soaking 10 days	Average shearing strength in lbs. sq. in.
½	O. K.	O. K.	261
1½	O. K.	O. K.	289
2½	O. K.	O. K.	349
3½	O. K.	O. K.	294
5	O. K.	O. K.	257

Housing Contract in France Let to American Contractors.—MacArthur Brothers Co., Engineers and Contractors, New York and Chicago, have just been advised from their Paris office that they have closed a contract with the French Government for the construction of 2,000 houses. This is the beginning of a large housing development for the French Government, much along the same lines as the housing development undertaken by the United States Government during the war. MacArthur Brothers Co., in addition to their other large Government contracts, have built approximately 1,000 houses for the United States Shipping Board at Chester, Pa., and Gloucester, N. J.

Reinforced Gypsum Beams

A tentative report on the design of reinforced gypsum beams was presented at the 22nd Annual Meeting of the American Society for Testing Materials, June 24-27, 1919. As engineers and architects are becoming more and more acquainted with the structural value of gypsum and especially with the reinforced gypsum, and inasmuch as the latter has peculiarities that makes necessary special considerations in the design, the proposed articles for specifications are indeed timely and necessary.

Although, as stated, reinforced gypsum has peculiarities, yet on the whole the methods of design of reinforced gypsum follow those for the design of reinforced concrete. The authors are to be complimented on their using the same notation as is used for concrete. One of the peculiarities of gypsum is its low bond stress, and mechanical anchorage at the ends of all enforcing bars is recommended. The authors state that it may be assumed as a basis for design that when effective mechanical anchorage is furnished, the bond stress actually developed at any point along the bar is one-half of that computed on the basis of pure beam action, and that the remainder of the resistance is furnished by the truss action developed by anchoring the bars.

Test results indicate that the proportionate part of the tension developed by bond varies with the amount of load and that one-half is the approximate ratio at the maximum load.

Test results indicate that truss action in the beam due to anchorage of the bars comes into existence early in the test. They indicate also that there is little difference in the effectiveness per square inch of the bearing area of the anchorage whether the anchorage be furnished in the form of U-hooks at the ends of bars or in the form of bearing plates rigidly attached at their centers to the reinforcing bars. Assuming that the effectiveness is the same for the two cases the average bearing unit pressure may be considered a measure of the value of the anchorage.

Allowed stresses for compression, shear, bond and bearing are expressed in terms of percentage of the ultimate strength values of wet and dry specimens.

Superintendents Wanted for Government Ordnance Plant.—The new naval ordnance plant at South Charleston, W. Va., is about to begin the manufacture of armor plate, and forgings for guns of large caliber, entirely new lines of work for Government plants. The South Charleston plant is a $19,000,000 enterprise occupying more than 200 acres of land. The new plant is equipped with every modern appliance for the manufacture of its specialties, and will turn out annually 50,000 tons of armor plate, guns, projectiles, and miscellaneous ordnance forgings. The U. S. Civil Service Commission has announced for this plant the need of a superintendent of melting shops at $5,000 a year, a superintendent of forge shops at $5,000 a year, foremen of heat treatment of armor plate at from $10 to $14.40 a day, foremen of heat treatment of large guns at from $8 to $12.56 a day, foremen of 14,000-ton presses for armor and large caliber guns, at from $11.84 to $13.28 a day, foremen of small guns at $8 a day, and foremen of heat treatment of projectiles at $8 a day. Applicants for these positions will not be given scholastic tests in an examination room, but will be rated on their training and experience, weighted at 90 per cent, and their physical ability, weighted at 10 per cent. Detailed information and application blanks may be obtained from the U. S. Civil Service Commission, Washington, D. C., or from the secretary of the local board of civil service examiners at the post office or customhouse in any of 3,000 cities.

Use of Bulk Cement for Railway Bridge. Bulk cement delivered in open top cars was used in the construction of a reinforced concrete bridge on the Zionsville improvement by the Big Four Ry. The open top cars were covered with tarpaulins. They were unloaded with a clam shell into a storage shed having a capacity for 12 cars. The filling and emptying of the shed by the clam shell was facilitated by having the roof make with removable sections. The bridge contains 6,200 cu. yd. of concrete.

Time-saving Method of Finding Right Column in Large Tables.—Finding the right columns on tables containing computed weights, measures, and costs of material in a manufacturing plant required nearly as much time as would be consumed in figuring the extensions that were being sought, an auditor discovered. The tables were so large that rulers had to be used to find both the horizontal and vertical columns. A 50 per cent reduction in time has been afforded, writes A. H. Dusser in System, by pasting the tables on large cylindrical rollers fastened in a box, or holder, with convenient cranks for revolving them. The first column of figures at the left and the first line across the top represent, for instance, inches. To get the number of square inches in a sheet of metal 19 by 23 in., the computer turns the cylinder to the figure 19 and the required number of square feet is found immediately over the figure 23 on a strip of blue print paper containing the same figures as the top row, which is pasted under the glass top parallel with the cylinder.

Concrete Building Blocks Faced with Marble.—The U. S. Bureau of Standards during the past month has been making tests of concrete building blocks faced with marble, to determine the strength, security of bond, and resistance to the action of frost. The results of this work showed that blocks of this character are suitable for use in construction. They are of some importance in that they will permit of the utilization of waste marble, at the same time affording a very attractive facing material.

Personals

Blair Boyle, county engineer of Geary County, Kansas, has resigned to accept appointment as county engineer of Bourbon County, Kansas.

The Condron Co., engineers, specializing in the design and supervision of construction of industrial buildings, 1433 Monadnock Bldg., Chicago, has opened a branch office at 632 Central Savings & Trust Bldg., Akron, O., in charge of Mr. C. L. Post, vice-president.

Arthur H. Blanchard has been appointed professor of highway engineering at the University of Michigan to occupy the chair recently established by the Board of Regents. He will retain his consulting office at Broadway and 117th St., New York City, until Sept. 15th, after which he will be located in Ann Arbor, Mich.

Charles W. McKay has taken charge of the appraisal division of L. V. Estes, Inc., industrial engineers, 202 S. State St., Chicago. The division specializes in the appraisement of industrial properties for Federal income tax purposes and in the appraisement of public utility properties in connection with rate cases.

Carl F. Meyer resigned as chief engineer for the Morgan Park Co., at Duluth, Minn., on Aug. 1. He has been connected with this housing project for the last six years, being for five years in charge of its design and construction as chief engineer to Morell & Nichols of Minneapolis and for the last year in charge of the engineering and maintenance work for the owning company.

Arthur F. Taggart and R. B. Yerxa have formed a partnership under the name of Taggart & Yerxa and have opened a testing and analytical laboratory at 165 Division St., New Haven, Conn., where they will act as consultants on the operation or design of plants for the treatment of ores and metal plant wastes and for crushing and handling rock.

T. Dantzig, G. A. Pfeiffer and J. F. Ritt have formed the firm of Dantzig, Pfeiffer & Ritt and have opened offices at 500 W. 116th St., New York City, where they will carry on a practice as consulting mathematicians, undertaking the handling of all problems arising in industry for the solution of which the knowledge of a mathematical specialist may be necessary. Each of the members of the firm has been privately engaged for some time in work of this nature, in addition to his other professional activities, and it was at the suggestion of clients that the decision was made to set up a consulting service which would extend to the industrial world the resources of modern pure and applied mathematics. Dr. Dantzig is a graduate of the University of Paris and of the Ecole Supérieure d'Aéronautique et de Construction Mécanique. He has taught at Indiana University and at Columbia. During the war he was in charge of the mathematical work of the instrument section of the U. S. Ordnance. Dr. Pfeiffer received the degree of Mechanical Engineer from the Stevens Institute of Technology and the degree of Doctor of Philosophy from Columbia University. He has taught mathematics at Harvard, Princeton and Columbia. He is an associate editor of the Annals of Mathematics. Dr. Ritt took the degree of Ph. D. at Columbia University. He was for three years at the Naval Observatory and has since taught mathematics at Columbia. During the war he was one of the chief ballisticians in the U. S. Ordnance.

Industrial Notes

The Duff Mfg. Co., manufacturers of lifting jacks, is constructing an addition, 160 by 80 ft., to its works at Pittsburgh. The new building is designed to accommodate the forge shop and heat treating department.

The Berow Machinery Co., Inc., is now located at 220 W. 42nd St., New York City, and will handle contractors' machinery and equipment. The company has its own motor trucks, and with a warehouse within thirty miles of New York, is prepared to give quick service

The Chicago Pneumatic Tool Company announces the removal of its Cincinnati office from the Mercantile Library Building to the Walsh Building, Pearl and Vine St., where a service station with a complete stock of pneumatic tools, electric tools, air depressors, oil engines, rock drills and repair parts will be maintained.

The promotion and inspection bureaus of the Universal Portland Cement Co. have been combined under the name of "Service Bureau." J. H. Libberton, formerly "Engineer Promotion Bureau" and "Inspecting Engineer," located in the general offices of the company at Chicago, becomes manager of the Service Bureau; G. E. Warren, assistant manager; J. W. Lowell, eastern manager, Pittsburgh; J. H. Chubb, northwestern manager, Minneapolis; and O. L. Moore, chief cement inspector, Chicago. The two bureaus which were combined formerly had separate and distinct duties, the Promotion Bureau handling special service and furnishing of information to cement users and the Inspection Bureau having charge of the physical testing at the mills.

The Oshkosh Manufacturing Co., Oshkosh, Wis., has just completed the establishment of a chain of service stations throughout the United States for the benefit of its patrons. These service stations carry a complete line of repair parts for all Oshkosh machines and maintain fully equipped shops for either repairing or completely rebuilding Oshkosh machinery. An engine and machinery expert is in charge of each repair shop. Besides these fully equipped service stations a large number of sub-stations have been established. Not all of the sub-stations carry a complete line of parts or maintain repair shops, but if they do not they can get this service within a very short time. By this service plan, it is stated that a needed repair can be obtained by the machine owner within a few hours—24 at the longest.

J. W. Wooley, General Sales Manager, Oshkosh Manufacturing Co., the Man Who Conceived the Oshkosh Service Plan.

The members of the Associated Metal Lath Manufacturers have united on a co-operative campaign to promote a more extensive use of metal lath for fire resistance construction. The climax of this campaign will be metal lath week, Oct. 6 to 11, 1919, which is co-incident with Fire Prevention Week held under the auspices of the National Fire Protection Association, U. S. Department of Commerce, Boards of Fire Underwriters and other national organizations interested in fire prevention. During this week all of the member companies of the Associated Metal Lath Manufacturers will instruct their entire sales force and all agents to concentrate on metal lath as a fire resistive material. Special efforts will be made to link up metal lath with fire prevention in the minds of architects, contractors, dealers and the general public. Individual brand names will be avoided and all will work for a more general recognition of the fire resistive qualities of metal lath. The Association has arranged with the Society for Fire Resistive Frame Construction to distribute a design for a test house which is published by that society. Efforts will be made to have this house reproduced in as many localities as possible and set fire to it on Fire Prevention Day, Oct. 9. This test house is designed so that one-half is built with the usual wood construction and the other half of fire resistive frame construction using metal lath on the inside and metal lath and stucco with a fire resisting roof outside.

Trade Publications

The following trade publications have been issued recently:

Standard Buildings—The Austin Co., Cleveland, O. Catalog containing drawings, illustrations and specifications of each of the ten standard types of Austin buildings, together with information concerning the scope of Austin building service.

Fire Door and Shutters—Merchant & Evans Co., Philadelphia, Pa. Catalog of Evans "Almetal Fire Doors and Shutters and Star Ventilators"; 24 pages. Contains general description of the products, together with illustrations and erection plans.

Jacks and Column Clamps—Paul W. Koch & Co., 19 S. Wells St., Chicago. Circular, 6 pages. Illustrates and describes various types of jacks and column clamps for building construction; also gives costs on concrete work with adjustable jacks and column clamps.

Steel Window Handbook—Truscon Steel Co., Youngstown, O. The book is divided into three parts, the first section dealing with pivoted windows, the second with continuous steel sash and Truscon operator, and the third with counterbalanced types of Truscon steel windows. Details, tables, diagrams, etc., are included.

Factory Made Reinforced Concrete Products—Massey Concrete Products Corporation, Peoples Gas Bldg., Chicago. A 24 page catalog illustrating and describing in a general way the reinforced concrete products made by the firm. These include portable concrete houses, hollow reinforced concrete poles, bridge slabs and piling, etc.

Road and Street Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field if subscribed for as a weekly at $3.00 a year; but any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year (or any two monthly issues at $1.50 a year) and the 4 special quarterly issues will be sent without extra charge. Three of these special quarterly issues relate entirely to foreign engineering and construction practice, and the fourth is our annual "New Equipment Issue." The *articles* in the first two issues of each month (1st and 2nd Wednesdays) completely cover the municipal engineering and contracting field. The *articles* in the first and last issues of each month (1st and 4th Wednesdays) completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and last issues of each month (3rd and 4th Wednesdays) completely cover steam and electric railway location, design and construction. See the "mast head" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials

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Volume LII. CHICAGO, ILL., SEPTEMBER 3, 1919. Number 10

A $17,000,000,000 Road Improvement Program

The Highway Industries Association, in its weekly bulletin of Aug. 23, estimates that it will be necessary to expend $17,000,000,000 in the next 10 to 15 years for road construction if this country is to be properly developed and its transportation needs served. This expenditure, it is figured, would provide for the construction by the Government of a national highway system of approximately 60,000 miles, costing $2,000,000,000; the improvement by the states of 250,000 miles of state systems at a cost of $6,000,000,000; and the improvement of 300,000 miles of country and township roads at a cost of $9,000,000,000, of which two-thirds would be used for county systems and the remainder for earth and top soil roads. Even with this great amount of construction there would remain unimproved about 1,800,000 miles of earth roads.

A program such as outlined would require many more highway engineers than are at present available. Where would these engineers come from? Many, of course, might come from other branches of engineering; but it should be borne in mind that other lines of construction, now dormant, will in the near future start up again. The tremendous amount of work that must be done in the next few years—in railway improvements, in public works, and in the building field, for instance, will furnish employment for all engineers who have heretofore followed these lines of endeavor.

A study made this year by the United States Bureau of Public Roads showed that approximately 10,500 engineers draftsmen, etc., were required for the Federal and state highway work being carried out at present. This total does not include the engineers employed by cities, counties and townships. The figures of the Bureau showed that there were required 122 chief executives and administrators, 360 division engineers of the Federal Government, division chiefs of bureaus, division chiefs of highway departments, district engineers of highway departments, etc.; 3,630 supervising engineers and chiefs of party; and 6,350 junior engineers, rodmen, chainmen, draftsmen and other employes of similar caliber.

It is understood that Secretary Lane of the Department of the Interior will shortly issue a call for a national conference to consider various phases of courses in highway construction in the colleges and universities. A recent investigation indicated that only 25 of the 93 colleges investigated give a satisfactory fundamental training in highway engineering as a part of their civil engineering courses. In view of this it is apparent that such a conference is needed, and it is to be hoped that much good will come from it

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

Should "The Absolute Ton-Mile" Be Discarded for "The Commercial Ton-Mile"?

"The Commercial Vehicle" is advocating a new unit in terms of which the cost of motor-trucking should be expressed. It calls this new unit the "commercial ton-mile," which is defined as "being the total tons carried per trip multiplied by the total distance of the trip." The "commercial ton-mileage" of a trip would exactly equal the "absolute ton-mileage" were the truck to travel with a constant load exactly half the round distance of the trip and return empty.

We fail to see any economic advantage in the use of this new unit, other than a slight saving in time involved in recording the weights and distances hauled, and in computing the "absolute ton-miles." The "Commercial Vehicle" gives the following illustration of the work involved in calculating the number of "absolute ton-miles" on a trip where the load on the truck varies at short intervals:

Tons carried.		Miles covered.		Absolute ton-miles.
5	×	2	=	10
4	×	3	=	12
1½	×	4	=	6
2	×	2	=	4
0	×	8	=	0
½	×	2	=	1
2	×	1½	=	3
3	×	2	=	6
4	×	2	=	8
5	×	3½	=	17½
				67½

Speaking of this calculation, "The Commercial Vehicle" says:

"Determination of the ton-mile in this case by the use of the absolute formula requires 10 separate multiplications, one for each stop at which a portion of the load is delivered. If there had been 20 stops instead of 10, 20 multiplications would have been necessary; if 30 stops, 30 multiplications, and so on, provided the absolute unit were used.

"Furthermore, in order to determine the absolute ton-miles in the case just cited, an observer would have been necessary on the truck to weigh the portion of the load delivered at each stop and note the distance covered between each successive stop The driver could not do the work and drive the truck at the same time, for if he did, he would in all probability do very little driving. The employment of an observer on each truck to determine the number of ton-miles accomplished on each trip is out of the question."

The editor of "The Commercial Vehicle" seems to have lost sight of the fact that where frequent changes in the loading of a truck occur, there is usually a record kept of the weight of the consignment and the distance hauled, for the charges made to patrons for trucking are usually based on the absolute ton-mileage. Where delivery trucks are used by merchants, it is doubtful whether there is an economic advantage in keeping daily records of tonnage hauled. In such cases the best unit of trucking costs is the truck-mile, and not the ton-mile.

Wherever unit charges are made for service, whether the unit is the ton mile, the kilowatt-hour, or what not, it is always desirable to calculate operating costs in terms of the same unit. But it does not follow that operating costs should not be as reduced to other units. In fact high operating efficiency is rarely securable unless several different units of cost are used. In operating a steam railway, the train-mile is a unit commonly used. Electric railways use the car-mile. In addition they have other cost units, such as the track-mile, the kilowatt-hour, etc. One of the greatest economic mistakes made by all railways is the failure to use a great many more cost units. For example, electric railway companies seldom record both construction and maintenance costs of pole lines per pole and per mile of wire of given classes and sizes. In consequence of such failure, both construction and maintenance costs are higher than they need be.

"The Commercial Vehicle" in seeking to eliminate the absolute ton-mile unit, is making an error of a sort that is not uncommon. Simplicity and efficiency are not synonymous. Low clerical expense does not usually result in low operating expense, but the reverse.

Who Should Pay for Our Highways and How?

Should the owners of vehicles pay for the use of the highways? If so, how and to what extent? The earliest improved roads in America were mostly private toll roads, which never were popular. The theory became prevalent that highways should be "free," and toll roads were accordingly purchased and made "free" by the states. While toll roads thus became "free," some one still had to pay for their upkeep as well as the interest on the investment. That "some one" has been the taxpayer. But why should a taxpayer be required to pay for a service without regard to the value of the service to him? This is a question that has never been answered satisfactorily.

If roads should be "free," why not have "free street" railways and "free" steam railways? In fact it is being seriously urged right now that Uncle Sam should continue indefinitely to meet the present railway deficit by taxation, and that cities should pay by taxation the deficits of the street railways. Only a few more steps need be taken to reach complete "freedom" of use of all kinds of railways.

Obviously the term "free highways" is a delusive term, for some one must pay for them. There are no truly free highways save those that nature has provided for water and air ships. The problem therefore simmers down to this: What is the most economic way to secure adequate highway transportation at the least cost to the community as a whole?

Where real estate taxpayers are required to pay the entire cost of roads and streets, there is invariably strong resistance to highway improvement, for many a taxpayer feels that the improvement is not worth its cost to him. No reasonable man rebels at paying for an improvement or a service all that it is worth to him. But nearly all men object to paying for improvements or services from which others derive greater benefit at less cost. In short, there is invariably great opposition to charges that are not proportionate to benefits enjoyed. It is this opposition that has checked the development of our city and country highways.

Illinois voted for a $60,000,000 bond issue for roads when a law was drawn that made the owners of motor vehicles foot the entire bill. Motor car licenses are to pay the bond interest and sinking fund annuities. While this is a step in the right direction, it is not only an inadequate step but it is not entirely equitable. Each motor vehicle, under this Illinois law does not pay for the use of state roads in proportion to its individual use. For example a vehicle that travels 30,000 miles a year pays no more than one that travels 3,000 miles a year.

An ideal method of charging for the use of a road would be one that involves a fixed annual charge per vehicle plus a mileage charge. Thus for a passenger vehicle weighing one ton the fixed annual charge might be $10 plus one-quarter cent per mile traveled. It is not practicable to secure the annual mileage of each vehicle, but it is practicable to tax gasoline and thus secure a payment approximately proportionate to the mileage and weight of each vehicle. A 15 per cent tax on the retail price of gasoline would yield about a quarter of a cent per ton-mile of dead weight of vehicle.

In our last Road and Street issue C. A. Mullen, director of the paving department of the Milton Hersey Co., of Montreal, suggested a tax on gasoline, for the purpose above outlined. In England prior to the war there was a 4 ct. per gallon tax on gasoline, which motorists did not oppose. Mr. Mullen points out that there would be some difficulties in applying such a tax, but none that is insuperable. For example, gasoline used for motor vehicles would have to be segregated from gasoline used for other purposes,

Civil engineers should study this economic problem carefully. Having reached a definite conclusion they should endeavor to secure changes in laws relating to assessments for roads and streets. All existing laws are ecomically defective, because they were devised by men that were not trained economists. Laws of this character are really economic instruments, quite as much so as an engineer's specifications for a structure. An economic instrument should be designed by an economist.

What Can Be Done to Accelerate Municipal Improvements?

According to the Daily Bond Buyer of New York municipal bonds totaling $378,124,000 were sold during the first seven months of 1919, as compared with $152,694,000 for the corresponding period of 1918, and $349,082,000 in 1914. On its face this would seem to indicate that expenditures for city improvements are back to normal, but it should be remembered that construction costs are about 80 per cent higher than they were in 1914. Hence bond sales for the first seven months of this year should have been about $630,000,000 to equal in purchasing power the $349,082,000 sold in 1914.

Municipal improvements will not reach the prewar level very soon unless one of two things is quickly done: (1) Deflate the currency and bank deposits so as to increase the buying power of the dollar; or (2) increase the borrowing power of municipalities. The latter step should be taken, even if the first is also taken, for city improvement should not be restricted by antequated charters.

The borrowing power of a city is usually limited to about 2.5 per cent of the assessed valuation of the real estate in it. Real estate valuations have not been materially raised in the last five years, and there will be vigorous opposition to any attempt at increasing assessed values. Hence the most practical move will probably be to secure an increase in the allowed percentage of debt limit. Not only in the interest of the public but of the thousands of engineers in the employ of cities, should engineering societies take the lead in securing changes in city charters that will enable cities to go ahead with municipal improvement at a satisfactory rate.

One of the many reasons why governments are less progressive than private companies and individuals is the difficulty of securing adequate capital Only under the stress of war is it usually easy for a democratic government to secure all the needed capital without interminable delays. Civil engineers experienced in public works know how frequently their recommendations for construction expenditures are either ignored or pigeon-holed. Even when politicians read and understand the reports of engineers—which is seldom—there is apt to be procrastination, for the average politician waits to see what the public opinion will be. Public opinion at best is slow in forming, and at worst it refuses to form. Moreover a few active opponents of a proposed improvement can often block it for years; witness the 25 years that it has taken to overcome the opposition of farmers to adequate expenditures for highways. Similarly in cities, the owners of buildings that are leased to tenants have usually opposed adequate expenditures for pavements. The tenants are only mildly interested in street improvement, whereas the landlords are keenly interested because of their assessments and taxes. The consequence is that this active minority has been so effective in its lobbying that not half the street mileage of American cities is paved at all, and the other half is paved inadequately, taking it as a whole. Against these militant minorities that oppose public improvements so effectually there has seldom been an equally militant minority organized to secure adequate improvements. Spasmodically a chamber of commerce may undertake to arouse public opinion in behalf of some improvement. Occasionally some public-spirited individual or newspaper may conduct such a campaign. As a rule, however, public works improvements lack aggressive, intelligent support. Engineers, above every other class, are capable of judging the economic merit of any public works improvement; but engineers have hitherto been content merely to report on projects. They have given no aggressive support to their own plans or to the plans of other engineers. The time has come to abandon this antequated policy of professional dormancy.

Increased Revenue for Georgia Highways.—The House of Representatives of the Georgia Legislature has amended the State Motor Vehicle Law so that it will provide $2,500,000 annually for road work. Under the existing law the state receives between $350,000 and $400,000. Under the law the license fees for trucks ranges from $20 for 1-ton to $200 for 4 to 5 ton trucks.

Political Economy and War

To the Editor: I have been reading several of your articles on "Political Economy as a Science" and I was particularly interested by the letter of Mr. Jakobsen in your issue of Aug. 20, 1919.

I would like to know who first said that there was any such science. All of us have read books and theses on various subjects which implied that such a science existed somewhere on the map. While in Paris watching the performance of the peace delegates I noticed a number of eminent practitioners of the aforesaid science. On being questioned they admitted that the adjudication of a just peace rested almost exclusively on their brawny shoulders and spectacles. Like Atlas of old they were somewhat bowed through the excessive weight of their responsibilities. The odd part of the matter was that one eminent practitioner who must have known most of the rules of the game, a short time before August, 1914, predicted that there never could be another general war in Europe. After the war had been going on several months another gentleman equally wise and learned predicted that it could not last over six months. They were not a bit discouraged but had set out to stop it After it was stopped by military force temporarily they announced that they had been successful in their endeavors and cited the Treaty of Versailles to prove the statement. Somehow there has been a lack of co-operation on the part of the war. It hasn't stopped as yet and bids fair to go on for a generation. Somebody apparently has failed to observe the rules of the game and an umpire should be appointed to make the players conform to the rules.

Wars are won and lost by something akin to the doctrine of stresses. The ability of a nation to carry a load cannot be judged by the size of the load altogether. If that were true a general in the field would spend all his time with the Q. M. Corps, the Ordnance Department, etc. While they are important parts of the machine the most weight must be given to the esprit de corps of the actual combatants. As an illustration of this take the first battle of the Marne. The Germans had 200,000 more men than the French and everything in the way of equipment was in their favor. Yet General (now Marshal) Foch, in command of the army of the center, after having both his wings driven back, advanced his center, broke the German center and forced the retirement of the best drilled and equipped army in the world. There is a good reason why this always will occur, but is anything on the subject to be found in the rules of political economy? Is there anything to show that the nations which so ardently desire their political freedom will be as well off from an economist's point of view as they were under the old regime?

The war will have far reaching economic effects, but were these results brought out by anything we ordinarily call the rules of political economy? The present turmoil in certain parts of Europe show that the nation apparently the poorest equipped to carry on a war will prolong it after the well-to-do nations are satisfied to quit.

This would never happen in a book on the science of political economy.

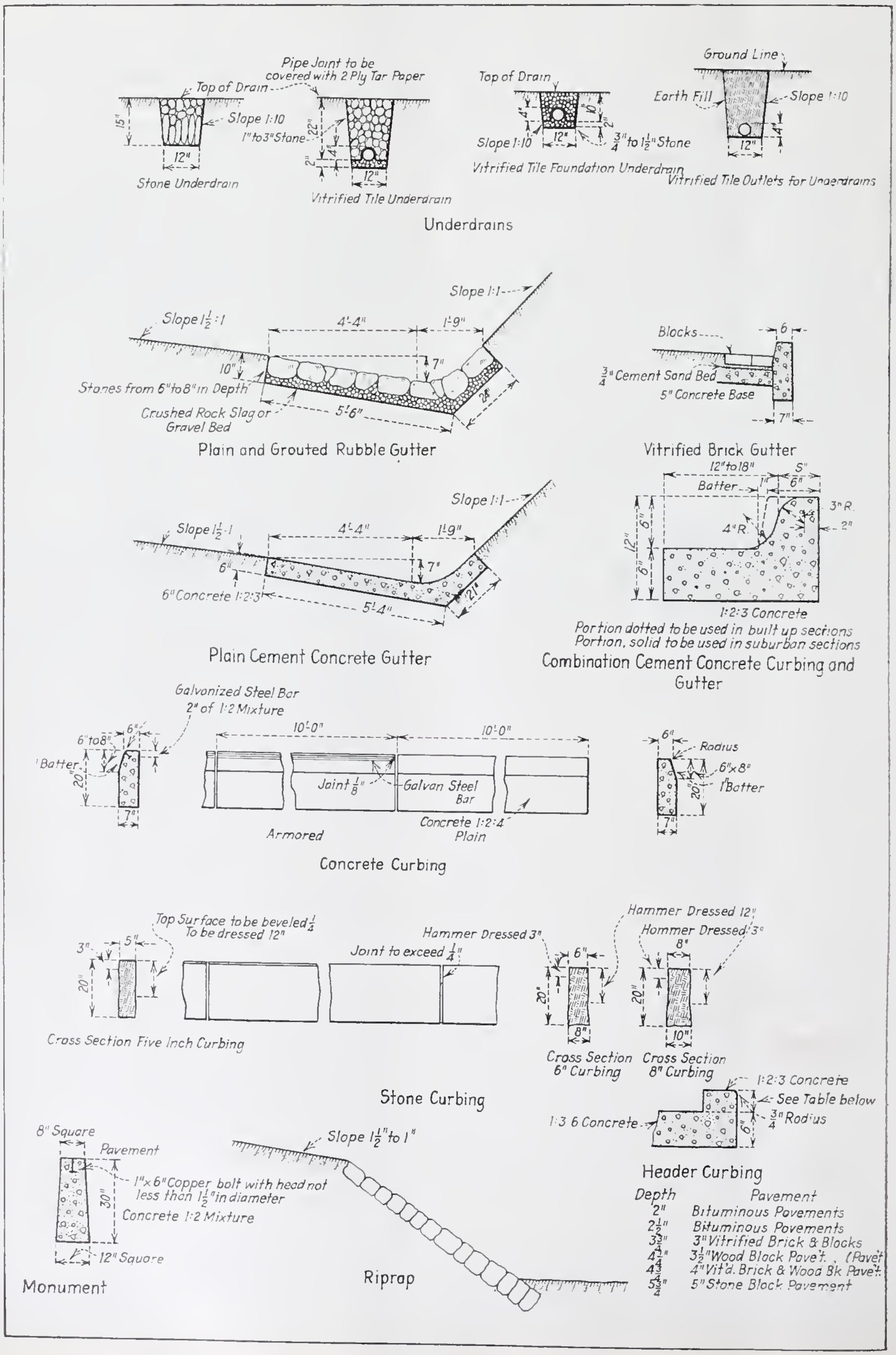
Mr. Jakobsen's letter giving the instance of the 42 km. guns brought this all to mind and also an instance of what science and experiment have hitherto demonstrated. According to the rules of exterior ballastics the maximum angle of fire is 45° for the greatest range. Everybody has proved it time and again. Having been a part of the target for the Big Bertha, I became interested in its performance. The information I received was that its angle of fire was about 60 The maximum height of its trajectory was about 35 km. By reason of its height the projectile reached a stratum of rarified air which offered less resistance than a lower one at the 45 and the range was much longer than by the latter method.

When old and apparently well established rules of mechanics are upset in this fashion it would seem that some of the crudities of so-called political science, which are based largely on opinon, might be revamped with profit to all concerned.

PAUL M. La BACH.
Engr. Water Service, Rock Island Lines

Chicago.

Standard Details of Pennsylvania State Highway Department for Minor Features of State Roads



Depth	Pavement
2"	Bituminous Pavements
2 1/2"	Bituminous Pavements
3 3/4"	3" Vitrified Brick & Blocks
4 1/4"	3 1/2" Wood Block Pave't. (Pave't
4 3/4	4" Vit'd. Brick & Wood Bk Pave't.
5 3/4"	5" Stone Block Pavement

Cost of Surveys for Federal Aid Roads Project in Kansas

The following figures relate to surveys made in the early part of 1918 for a Federal Aid road project in Labette county, Kansas. The work covered approximately 44 miles of highway, divided into four sections, as follows: Section A, 9.25 miles; B, 10.1 miles; C, 10.83 miles; D, 13.91 miles.

The transitman received $100 per month until May 1st, excepting two days due to a change of transitmen. From June 12th to June 27th, the transitman received $150 per month. The helpers received $2 per day until March 1st, when they were paid $3 per day. The time was derived from the actual number of days worked, as the helpers were working by the day and the transitman worked in the office during inclement weather.

A cheap cloth tape which had been removed from its case and the free end allowed to drag on the ground was used in measuring, it being impractical to be continually rolling and unrolling the tape. The tape was much easier to handle in this way and being inexpensive the time saved more than offset the additional cost.

Bench levels for Section A were started on Jan. 23 and completed on Feb. 5. The following is a summary of the work for the four sections:

Section	Error of closure.	Error of closure-mile.	Distance between B. M's.	Length of shot	Miles-day.	Miles of road checked-day.	Length of circuit.
"A"	.032	.0060	1,113	324	2.11	1.85	2.31
"B"	.036	.0059	1,532	513	2.66	2.34	2.90
"C"	.026	.0059	1,196	352	2.32	2.32	2.17
"D"	.047	.0241	1,677	331	2.20	2.02	1.60
	.141	.0419	5,518	1,520	9.29	8.53	8.98

Average closure...... $\frac{.141}{4}$ — .036.

Average error of closure / mile.... $\frac{.0419}{4}$ — .0105.

Average distance between bench marks.. $\frac{5,518}{4}$ — 1,380 ft.

Average length of shots.. $\frac{1,520}{4}$ — 380 ft.

Average miles / day..... $\frac{9.29}{4}$ — 2.32

Average miles of road checked / day..... $\frac{8.53}{4}$ — 2.15.

The result of inexperienced help is clearly shown in Section "A" under miles per day. The effect of rough, hilly country is also shown in Section "D" under miles per day, and error of closure. The slower progress made on Section "A" was due in part to disagreeable weather. Sections "B" and "C," over which progress was more rapid, are similar in topography to "A." Three circuits were re-run, and two additional circuits have poor closures but were not rechecked, owing to the limited time in which to finish the survey, this being another cause of the poor closures in Section "D."

Center line surveys on Section A were started on Feb. 6 and completed Feb. 15. A summary of this work for the four sections follows:

Section.	No. of miles / day	Length of shots.
"A"	1.16	1,815
"B"	1.44	1,624
"C"	1.67	1,518
"D"	1.46	1,295
	5.73	6,352

Average number of miles / day... $\frac{5.73}{4}$ — 1.43.

Length of shots...... $\frac{6,352}{4}$ — 1,588 ft.

Section "A" shows the least number of miles per day as in bench levels and for the same reasons as stated before; the rate would have been proportionately smaller had it not been for the longer shots. In the same manner the shorter shots in Section "D" retarded the work.

Cross sectioning was started on Section A on Feb. 11 and finished Feb. 28. The following is a summary for all the sections:

Section.	Error of closure.	Length of foresights and back-sights.	No. of miles / day.	No. of shots / day.
"A"	.033	272	1.23	570
"B"	.066	327	1.56	732
"C"	.027	302	1.48	[illegible]
"D"	.063	298	[illegible]	[illegible]
	.189	1,199	5.92	2,654

Average closure...... $\frac{.189}{4}$ — .047

Average length of foresights and backsights $\frac{1,1[illegible]}{4}$ [illegible] ft.

Average number of miles / day. . $\frac{5.93}{4}$ — 1.48

Average number of shots / day. .. $\frac{2,654}{4}$ 664

As before, Section "A" indicates a slower rate of progress while Section "D" shows the best progress, which can be partly attributed to the fact that less shots were taken per distance traveled than upon the other sections. Rainy weather retarded progress appreciably on Section "C." The closures on Sections "A" and "C" compare very well with the bench level closures for the same sections. This would seem to indicate that an accurate line of levels can be run in connection with the cross sectioning by using the necessary precautions. The larger errors accumulated in Sections "B" and "D" are attributed to inaccuracies resulting from too fast work.

The labor cost of the surveys was as follows

BENCH LEVELS

Section	No. of days	No. of men.	Rate	Total	Cost per per mile
"A"	5	1	$3.85	$19.25	
		1	2.00	10.00	$3.16
"B"	[illegible]	1	3.85	16.68	
		1	3.00	13.00	2.94
"C"	1.66	1	3.85	17.94	
	2	1	2.00	4.00	
	2.66	1	3.00	7.98	2.76
"D"	2	1	3.85	7.70	
	1.87	1	4.81	23.42	
	6.87	1	3.00	20.61	3.00

CENTERLINE

Section	No. of days	No. of men.	Rate	Total	Cost per per mile
"A"	8	1	$3.85	$30.80	
		2	2.00	32.00	$7.01
"B"	7	1	3.85	26.95	
		2	3.00	42.00	6.83
"C"	6½	1	3.85	25.03	
		2	3.00	39.00	5.91
"D"	9½	1	4.81	45.70	
		2	3.00	57.00	7.38

CROSS SECTIONS

Section.	No. of days	No. of men	Rate	Total	Cost per per mil
"A"	7½	1	$3.85	$28.88	
		2	2.00	30.00	$6.[illegible]
"B"	6½	1	3.85	25.03	
		2	3.00	39.00	[illegible]
"C"	7½	2	3.00	34.00	
	1	1	4.81	4.81	
	6⅓	1	3.85	24.38	5.83
"D"	7.79	1	5.77	44.95	
		2	3.00	46.71	7.08

An automobile was used on the survey for five months. The total miles traveled in the survey was estimated at 2,187. This number was arrived at by taking the distance to the center of the road and multiplying it by twice the number of trips, some days there being two trips out and back when the party came in at noon.

The total expense of running the car for the five months was $133.89, less one-eighth the amount the car was used for other purposes, = $133.89 — $16.74 = $116.95. Depreciation = $385 (cost price) — $200 (selling price) = $185. The car had been out nine months when the survey began, was used on the survey five months and had been in use 21 months when sold. The amount of the total depreciation charged to the use of the car during the survey was one-third, or $61.66. The total expense of car was $178.61 for 2,187 miles or $0.082 per mile.

The instruments and materials used on the surveys were as follows

BENCH LEVELS

	Cost.	Depreciation	Amount
Level and rod	$ 50.00	2½%	$ 1.25
Field books and pencils			1.15
			$ 2.40

CENTER LINES

	Cost	Depreciation	Amount.
Stakes	$ 57.15	....	$57.15
Transit	150.00	5%	7.50
Axe	1.00	50%	.50
Tape	5.44	15%	.82
2 cloth tapes	5.00	25%	1.25
Field books and pencils	2.25	..	2.25
Flag poles	[illegible]	5%	.25

Kiel	1.00	.....	1.00
Nails	.25	.....	.25
			$70.97

CROSS SECTIONS.

	Cost.	Depreciation.	Amount.
Level and rod	$ 50.00	2½%	$ 1.25
Field books and pencils	2.25	.....	2.25
! cloth tapes	4.00	.....	4.00
			$ 7.50

This gives a total of $80.37 or 3.697 ct. per mile.

Allowing for one-fourth time of the County Engineer for 5 months at $166.66 per month gives a cost of $208.33 divided by 2,187 miles or 9.5 ct. per mile. Figuring in this cost the totals for the surveys were:

	Bench levels.	Center lines.	Cross sections.
Labor	$130.58	$300.48	$277.77
Car	47.64	67.24	46.50
Instruments and materials	2.40	70.97	7.50
County engineer	55.20	77.90	44.02
Totals	$235.82	$516.59	$424.44
Cost per mile	$ 5.35	$ 11.72	$ 9.84

The labor cost of preparing the plans follows:

County engineer, ¼th time from Feb. 1 to July 1, 1918, at $833.33	$ 208.33
County engineer, 1/7th time from Jan. 1 to July 1, 1919	142.86
County engineer, ½ time from July 1 to Aug. 15, 1919	125.00
Assistant engineer, 45½ days, at $3.80	157.64
Assistant engineer, 2 months, at $125	250.00
Assistant engineer, 1 month, at $125	125.00
Assistant, 7 weeks, at $150 per month	258.61
Assistant, 4 days, at $4.17	16.88
Assistant, 6 days, at $3.70	33.50
Assistant, 9 days, at $5	45.00
Assistant, 3 months, at $150	450.00
Assistant, ¼th time for 3 months, at	131.25
Miscellaneous help	55.22
Total	$1,999.89

As the surveys covered 44.09 miles of highway, the labor cost of preparing the plans was $45.36 per mile.

The cost of supplies and use of office equipment for the plans was as follows:

Ink, pencils, erasers, etc.	$ 5.06
Value of office fixtures, drawing instruments, etc., $300.30; depreciation at 4%, or	12.01
Total	$17.07

On the basis of 44.09 miles of road this gives a cost of $0.39 per mile.

The cost of blue print paper was 11 ct. per sheet; the cost of printing, trimming and binding was 14 ct., making the total cost per sheet 25 ct. Materials as follows were used in preparing the plans for the four sections:

216 sheets blue print paper at 25 ct.	$ 54.00
90 sq. yd. plain profile cloth at 70 ct.	63.00
90 sq. yd. cross section paper at 20 ct.	18.00
11.7 sq. yd. tracing cloth at 37 ct.	43.29
Total, 44.09 miles of road at $4.05	$178.29

This gives a cost of $4.05 per mile of road for the blue prints.

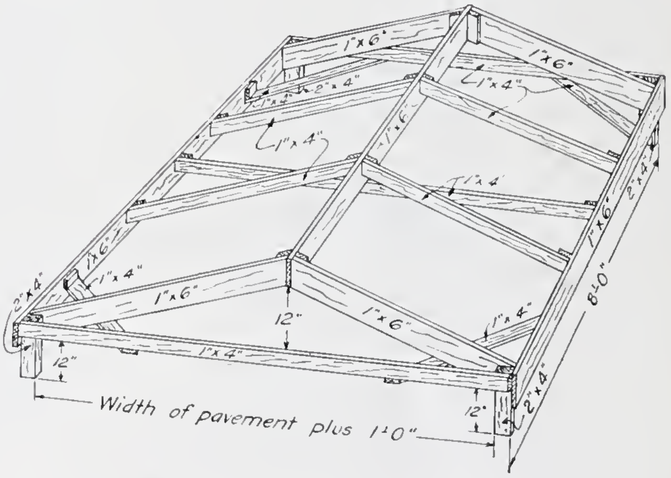
The cost of the plans was $48.22 per mile, and the cost of the surveys was $26.69 per mile, giving a total cost of $74.91 per mile. We are indebted to E. L. Hageman, resident engineer, Section A, Federal Aid Project No. 2, Labette county, Kan., for the above data.

$300,000,000 Expended in 1918 on Rural Roads and Bridges.—Based on complete reports from 44 of the states, cash expenditures on the rural roads and bridges of the United States for the calendar year 1918 amounted to $286,098,193. To this should be added the value of statute and convict labor, which can not be fixed with any great degree of accuracy but probably amounted to not less than $14,000,000, thus making the grand total expenditures for the year $300,000,000. This total is made up of the actual expenditures for such items as labor, materials, supervision and administration directly connected with the construction, improvement, and upkeep of public roads and bridges outside the limits of incorporated towns and cities, and does not include any item for sinking fund payments or redemption and interest on road and bridge bonds. The year 1918 offered and unprecedented condition in practically all lines of highway work. There was not only a tremendous increase and expansion in the amount of heavy truck traffic on public roads and an unprecedented shortage in regard to road materials, labor, and ready funds, but also a decided increase in maintenance work, which was, however, partially offset by a decrease in the amount of new construction.

Methods of Protecting Concrete Pavements Laid in Warm Weather

Most concrete pavement construction is carried out during the hottest part of the year. If suitable measures are taken to protect the concrete from hot sun and drying wind, strength and wearing qualities of the pavement will be considerably improved due to the fact that water is retained in the concrete during the early hardening period. Various methods of protecting the concrete are described in a circular issued last month by the Portland Cement Association, to which we are indebted for the matter that follows.

As the hardening of concrete is not a drying process, the newly-laid concrete must be protected against evaporation of necessary moisture. Concrete hardens best and most uniformly in the presence of moisture. Water introduced in mixing the concrete is necessary to the chemical changes that take place when cement and water are combined. Mixtures may be properly proportioned, concrete mixed to the right consistency and properly placed, yet if the work is exposed to hot sun and drying winds its final strength will fall below maximum. Direct heat from the sun and hot, drying winds from across open fields in open country must be guarded against on concrete roads under construction. Residence streets are often partly shaded by trees and because of this are subjected to uneven drying unless the concrete is protected. One cause of rapid evaporation of water from newly-placed concrete on street and alley work is heat reflected from buildings adjacent to the work. The walls of a building exposed to the sun will continue to radiate heat for some hours after direct rays of the sun no longer strike the building surface. This situation always demands close attention and extra care must be taken to protect new concrete laid in such locations.



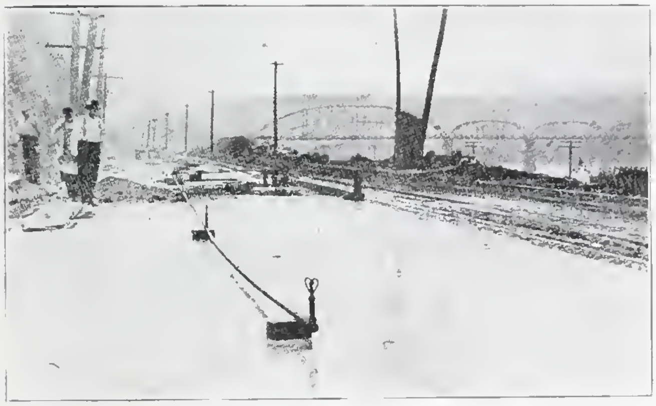
Suggested Design for Light Frame to Hold Canvas Over Newly Placed Concrete Pavement.

Canvas Covering.—Immediately after a section of pavement has been finished during hot or windy weather, it should be covered with canvas. Frames are set up to hold the canvas away from the surface, thus preventing injury to the fresh concrete. Such frames are usually made in sections that may readily be moved forward to new positions. The canvas covering is not removed until the concrete has developed initial hardening. Usually this takes place in a few hours. The concrete is then given a thorough sprinkling and protected by ponding or with a layer of earth or sand kept moist by frequently sprinkling. This protective covering prevents the rapid drying out of the concrete and permits the hardening process to proceed at a rate which will produce the strongest concrete.

Curing by Ponding.—The ponding method of curing is usually preferred on level stretches of pavement or sections where the gradient does not exceed 2 per cent. After the canvas has been removed and the surface of the concrete sprinkled, dikes of earth are built along the sides of the pavement. These should be high enough to maintain constantly a 2-inch depth of water over the crown of the pavement. To prevent too great a loss of water by seepage, a secondary longitudinal dam is sometimes constructed 2 ft. or so in from the edge of the pavement. This helps to insure greater depth of water over the crown of the pavement.

Transverse dikes are built across the pavement at suitable intervals. On grades up to 2 per cent, ponding may be done by spacing the transverse dikes at as short intervals as necessary to secure the required depth of water over the crown. The water must be maintained at sufficient depth to cover the center line of the pavement at all times, but, as flooding must be timed so as not to deprive the mixer of the necessary water supply, the ponds are usually filled at the noon hour and in the evening and early morning. Water is kept on the pavement in this manner for at least 10 days and often for two weeks. When curing has progressed to the desired stage, the water is allowed to run off and the pavement swept and cleaned. At the end of 10 days or two weeks, hardening has so far advanced that weather conditions are not likely to affect the strength of the concrete adversely.

Traffic must be kept off the pavement, however, and it is good practice to keep up barricades until the concrete is 30 days old. This length of time is particularly desirable if heavy truck traffic is to use the road.



Sprinkler System for Curing Concrete Pavement.

Curing by Earth Covering.—An earth covering is often used instead of the ponding method of curing. This produces good results. After the canvas protection has been removed and the concrete has been sprinkled, a covering of earth, sand or other water retaining material 2 in. or more thick, is spread evenly over the pavement. This covering is thoroughly soaked at intervals frequent enough to prevent the earth from drying out. Sprinkling of the earth covering usually should continue throughout a period of two weeks and the covering be allowed to remain on the concrete for a week longer. The pavement is then cleaned off, the earth being used to even up the shoulders. Usually barricades are kept up another week before traffic is permitted to use the pavement. In cool weather, when hardening of concrete proceeded more slowly, the period of excluding traffic from the pavement is often lengthened.

Curing by Sprinkling.—On city street paving it is frequently inconvenient or impossible to protect concrete pavement during the curing period by earth covering or ponding. In such cases it is often possible to keep the concrete wet by means of sprinkler heads arranged at suitable intervals connected by hose to the city water supply system. Where the street is on a slight gradient, it may be that the line of sprinkler heads can be so arranged that the water flowing down the gradient will cover all portions of the pavement and thus reduce the number of outlets which must be provided. In arranging to cure the concrete by this method it is necessary to plan the work so that the water running off the pavement being cured will not flow over newly placed concrete or onto the earth subgrade soon to be concreted.

Conditions Making Protection Unnecessary.—Generally speaking, the protective measures described in the foregoing are omitted when the temperature is near 50° F. Under such conditions concrete does not harden so rapidly and the drying out action is not so likely to occur, so the precautions described are not necessary.

Progressive Method of Road Improvement for Rural Districts*

By GABRIEL HENRY

Chief Engineer, Department of Roads, Province of Quebec

In a country with a comparatively sparse population grouped in centers generally remote from one another, the general problem of road improvement is solved by means of two methods which may be used concurrently according to the amount of money available. On the one hand there is the method generally followed for main communication highways known as "trunk roads." This method is the normal one which is of the same nature as that followed in building railways, with the same complete preliminary studies and a similar organization for carrying out the work. On the other hand, there is what is called the "progressive method," which is better suited for rural road properly so-called. The object of this paper is to call attention to this second method to describe it properly and make its advantages known.

The Need for Rural Roads in Quebec.—The population of the province of Quebec is scattered over a very large area, generally in groups and living on long ranges sometimes remote from one another, from railways and from main highways, at distances which, in a densely populated country, would be considered very great. The consequence of this is that every rural municipality has a very considerable length of roads under its charge. The average length of roads per municipality in this province probably exceeds 40 miles. Some townships have as much as 100, 150 and even 200 miles of roads under their control.

The population is chiefly an agricultural one and naturally has not sufficient capital for improving such a long stretch, all the more so owing to the fact that, outside the St. Lawrence Valley, the country is generally undulating and sometimes broken; on the other hand, agriculture and trade have greatly developed within the past four years, and the need of connecting rural municipalities with one another, with railways and highways is becoming more and more felt. The use of automobiles is increasing even in the most remote districts. Requests for roads, on which at least automobiles can run, are becoming more and more insistent every day and the problem is becoming complicated from a domestic standpoint. How can all these requests be even partly satisfied? Such is the question answered by the second method.

Needless work must be avoided and as little as possible of work offering but transitory or short-lasting advantages should be done. All the work executed should be with a view to real, progressive definite improvement, and preference should be given to the work urgently needed. Thus, the works on rural roads may naturally be classified in two principal categories: Works of a permanent nature, and works of a non-permanent nature.

This distinction, as will be seen further on, is very important not only from the standpoint of the capital to be spent in making roads, but also from a technical point of view. It also naturally applies to road-making according to the first method.

Works of Permanent Nature.—Permanent works comprise: Drainage, underdrainage; bridges and culverts; earthworks; special work, such as retaining walls, rip-rap, random rip-rap, etc.; work of minor importance, such as cobble gutters, small dry stone walls, earth basins, etc.; lastly, the foundation, which is one of the most important of permanent works.

All these works are called "permanent" because their duration must be unlimited and because the capital spent on them must be a life-long investment. For instance, reducing the slope of a hill from 15 per cent to 5 per cent, is a permanent work. Interest on the capital required for this work is and will always be represented by a lower cost per ton-mile as well as by reduction in the cost of maintaining the road, and the amount of interest will be all the greater as the traffic on the road increases.

As a rule, the cuts and fills for improving the profile of a road are permanent works. Deviating a road to get around a low-lying or wet spot, when drainage and under-drainage cannot be done and where no top course can be maintained except at a heavy cost; raising, by means of a fill, a road running through a low place in order to protect it from dampness and from flooding along a stream, are permanent works. All these works must be so arranged for that the capital to be spent on them will permanently yield good interest through the advantages they will procure.

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*From a paper prepared for the Canadian Road Congress.

The straightening of a road in order to decrease its length, is also a permanent work. If, for instance, one reduces by ½ mile the length of a road 4 miles long on which a wearing course has to be put which will cost $10,000 per mile, the total cost of that top course will be lowered by $5,000. Such straightening may sometimes be effected for a smaller sum, including the purchase of the land required, while the expense of its maintenance will be reduced by one-eighth. The more expensive top courses are, the greater will be the advantage of reducing their length by well-arranged straightening.

Concrete bridges and culverts to replace wooden ones, may last indefinitely if they are solidly and carefully built, and the interest on the capital spent on them will be represented by a decrease in the cost of maintaining the road. Wooden bridges are comparatively costly to keep in order and require to be rebuilt from time to time. This cost of maintaining and remaking bridges is heavier, as a rule, than the interest on the cost of properly built concrete bridges.

Economic Features of Permanent Work.—Generally speaking, the works called "permanent" in connection with road-making, are the same as for railways, less the cost of purchasing, transportation and laying ties and rails. To sum up, their feature, as we have just said, is the effecting of a life-long investment and they must always be understood and executed so that the investment may be an advantageous one. These permanent works also possess the following important characteristics:

If properly understood and carried out, the yearly cost of their maintenance will be greatly decreased. Such cost is practically independent of the volume of traffic. It is greater, as a rule, during the years immediately following their execution and it decreases gradually, as the years go by, to a certain fixed lower limit as the road settles down and nature establishes a new equilibrium in the place of that which was disturbed by the execution of the work. In good ground, the new equilibrium is very soon attained and the cost of maintenance rapidly drops to a trifle. But, in bad ground the cost, which may have been rather considerable at the outset and for some years, always ends by reaching its fixed limit.

The maintenance expenses of these permanent works consist chiefly in keeping the slopes in order, clearing the drainage system, repairing the drystone works and the foundations, for the latter often sink owing to uncontrollable changes in the regimen of the underground waters.

Such are the economic features of permanent works. Comparison with non-permanent works will bring them out still more clearly. From an economic standpoint, non-permanent works do not absolutely constitute a permanent investment, but are rather a yearly expense. In industrial accountancy, they would be considered as more or less transitory investments and be classed among those represented by cost of equipment. Expenditure in connection with them would be classed partly among the items interest, renewals, depreciation, and in the list of fixed charges, and partly among the items of labor, supplies and repairs in the operating charges.

Contrary to the permanent works, the maintenance expenses in connection with them vary with the traffic volume and also with their age. They are almost nothing during the first years after being done and progressively increase during a certain number of years, determined by the duration of their useful existence, which may, however, be lengthened by increasing the yearly cost of repairs and maintenance.

The non-permanent parts of the road consist almost entirely of what may be called "wearing-courses" or "top-courses" and correspond to the whole of the ties and rails in the case of railways.

As the wearing courses, which last for some time, are expensive as a rule, it can easily be seen that in the case of nonpermanent works, the items of interest, renewals and depreciation in the fixed charges on the one hand, and those of labor, repairs and supplies in the operating charges, on the other hand, are comparatively high, and that consequently the choice of top courses and their use is one of the most important problems in connection with road-making.

Typical Problem and Its Solution.—When we consider the general problem of improving the highways of a province or of a state, the foregoing remarks lead to the conclusion that in the case of roads, there is no drawback in doing permanent work progressively from year to year on roads, provided a well-defined plan has been adopted and is followed and that no work, or as little as possible of work, of a more or less temporary nature is done.

The following example will make this better understood: Let us take a road 40 miles long which connects two important rural centers or makes a short cut between two main roads and runs, for instance, through five villages and a district exclusively inhabited by farmers and by settlers far from one another; a road which the population is really unable to maintain properly owing to difficulties in connection with the nature of the land and lack of money: which is impassable during a portion of the year and on which automobiles can hardly venture. Let us suppose that at present, in order to go from one center to another, one must do so by rail or by a long round-about way and the five villages between the two centers are consequently isolated; that if this road was made at least passable, relations between the two centers and the villages would become more active, that the value of the properties along it and in the district generally would increase; and lastly, that this would greatly accommodate the traveling public in general, would promote the development of motoring as well as relations with the interior of the district and with neighboring districts.

On a length of 6 or 7 miles this road is encumbered with large boulders, there is a hill with a 20 per cent grade and two other long ones with a 15 per cent grade all three being actually climbed with difficulty; there are also eight low-lying spots impassable in rainy weather. The bridges and culverts, mostly wooden, are in bad condition and even dangerous. In many places there are dangerous and soft springy spots and bad holes. The remainder of the road is nearly passable. There are field stones in the adjacent fields and good gravel banks here and there in its vicinity.

The chief obstacles to the opening of this road are the three hills, the rocks in the road, the low-lying spots and the soft springy spots. If only these defects were removed the road would become passable and automobiles could run over it.

The problem is this: Shall the road be built immediately at a great expense according to the normal method followed in the case of an entirely modern road with an improved wearing course, or shall capital be spent progressively and judiciously on the works of a permanent nature most urgently needed to open it at once to traffic?

By virtue of what has just been said, there is certainly no doubt that the second method is not only the most justifiable, but also the more advantageous, all the more so as there are many similar cases in the country to be considered, the carrying out of which according to the first method would necessitate the immediate investment of a considerable amount of capital.

It seems reasonable, therefore, first of all to improve the hills and to fill in the low-lying spots with the stones to be found in quantities in the neighboring fields. This filling can be done at first on a sufficient width of road to allow for vehicles passing over such spots without danger and the road may afterwards be widened as funds become available. The boulders should be removed from the road and the soft spots permanently cured.

All these works are permanent and the money spent on them will be a good investment, they will not cost much and in a short time in a single season the road might be made passable for automobiles. Improvements may be made, year by year, until the whole permanent portion of the work is finished, including even the foundation. A modern top course should be laid as soon as it becomes necessary, beginning at the villages where traffic concentrates, in the vicinity of the churches and shops. It is curious to note, even with a small investment in permanent works of this nature, roads can rapidly be made passable when the farmers themselves work at the improvements and furnish the stone which they remove from their fields.

This manner of proceeding is called the "progressive method." It progressively increases the value of the immoveable property of the country. The capital so spent is, or should be, as has been said, a good investment. This method must not, however, be followed to an exaggerated extent, for when a trunk road has to be built, traffic rapidly becomes so considerable that the laying of a regular wearing course becomes necessary at once and, in such cases, the normal method is the only justifiable and recommended one.

Under Progressive Plan Details Are Studied Only as Need Arises.—When the progressive method is followed in improving a rural road, a complete study of the details and a general detailed plan with cross-section of all the road are not usually made beforehand. The details are studied only as need arises. Then it must not be forgotten that works which are not permanent or not of a sufficiently permanent nature must never be done and that all the capital spent on improvements must constitute a life-long and paying investment; and again that, in doing such works, they should be done so that it will never be necessary, when completing improvement work; to undo and do differently any works already done.

As rural roads are sometimes very winding and of irregular width, it is often difficult to obtain the land required for straightening them and equalizing their width. Consequently, when this method is followed in winding places of regular width, the axis of the road should be traced and given such a direction that it may, in each case, be prolonged in a straight line as far as possible, reserving enough land on either side between the ditches for the roadway proper and for suitable shouldering. The inequalities in the ditches and in the width of the shouldering may be attended to later on, but the roadway itself should be built in straight sections as long as possible. It is a permanent work which should not have to be begun over again later on. The straight sections should be connected by curves having as large a radius as possible This radius should never be less than 300 ft. With such curves care should also be taken to raise the outside of the road higher than the inside before laying the foundation.

Earth Work Under Progressive Plan.—In this method as in the normal method, earth work is divided into heavy and light work, but with a difference. As in the normal method, heavy earth work consists of large fills with cuts of which a special and complete preliminary survey, with plans and cross-sections must be made. Such work must be staked out separately, but may be performed in sections at different times as funds became available. In this method, light earth work usually comprises light grading, cleaning ditches, etc., outside of sections staked out for heavy earthwork. In these sections no heavy work is to be carried on. Such sections are also separately staked out. Light grading may be largely performed by means of the road machine, and is generally carried out without a special preliminary and complete survey, but under the superintendence of a competent foreman accustomed to such work. In this method, heavy earth work is reckoned by the cubic yard, light work by the mile. It must be added that road lengths requiring heavy earth work represent as a rule only a small proportion of the total length

It is useless to reduce gentle slopes but it should not be forgotten that a road with a very wavy longitudinal profile is most disagreeable. Hence all the slight undulations in the road should be machine levelled so that the slopes may everywhere be gentle and regular and their length nowhere be less than from 150 to 200 ft.

If 5 per cent be the maximum limit allowed for grades of steep hills, it is useless to reduce slopes of less than 5 per cent, unless they are too close and form narrow ravines, in which case it is better to reduce to 3 or 4 per cent, and sometimes less.

In the method of progressive improvement, it is better where there is no heavy earth work to do, and whenever possible, to proceed by successive thin layers which are beaten down by traffic one after the other and cause less obstruction. When to much digging is done at the same time and too deep layers of earth are spread on the surface of a road, the latter usually becomes impassable in rainy weather and dragging is more costly.

No road can be kept in good order if its substructure is damp. No wearing course, however costly it may be, can last on an insufficiently drained substructure. It is needless to insist on this universally admitted fact. Drying and draining the road are difficult undertakings and call for much experience, judgment and time.

Drainage and Underdrainage Essential Requisites for Starting Road Improvement.—To dry and drain a road there are two requisites First, to drain off rain and melted ice and snow as rapidly and completely as possible, second, to dispose of the dampness which the subsoil always contains.

The surface waters are discharged, subsoil moisture is removed by underdrainage. Drainage and underdrainage are the two essential requisites for starting road improvement They must be undertaken beforehand because a real and sufficient solidifying of the substructure through underdrainage often cannot be obtained in our climate before several months and sometimes a whole year and even more Drainage is obtained by means of a complete system of ditches, gutters, culverts and bridges.

Ditches should not be dug or maintained where they are not absolutely needed. Of the permanent road works, ditches are the most expensive to maintain and their length should be reduced as much as possible. They should also be made as shallow as possible. Deep ditches, besides being expensive to keep up, are very dangerous. Deep ditches are often supposed to dry the body of a road. It is not always the case; in this climate; it is so only in soils which easily part with their moisture.

Permanent ditches should be as straight as possible Winding ditches are more exposed to erosion by water and consequently cost more to keep up. The longitudinal slope of ditches should not be less than 5 in. per 100 ft. when it is possible without too much expense. Nor should the slope be too considerable, on account of erosion. Naturally in more resistant soil it may be more pronounced. They should empty rapidly and completely after rain and retain no stagnant water at any place. Their side slopes should not be over 45°. When the latter are steep, they should be strengthened by means of dry stone walls or rip-rap, at least up to a certain height. Where the slope is pronounced and the land non-resistant, the bed should be paved to prevent erosion, and the curves reinforced by dry stone walls. The gutters should be the continuation of the shoulders and no stagnant water should remain in them anywhere in hollows The outlets in which the ditches empty should be put in order and be large enough easily to carry off all the water they receive under the heaviest rains.

To sum up, the ditches, gutters, culverts, bridges and outlets all together should form a system capable of draining completely and as rapidly as possible and without erosion anywhere, the water from the heaviest rains and spring thaws, leaving no stagnant water in hollows.

In the subsoil there is nearly always a sheet of subterranean water at a certain depth. The depth at which it is met with varies greatly from one point to another. It varies also with the seasons and diminishes in the spring. In many places, the level of this sheet of water is almost flush with the soil and when the spring thaws occur it rises even above the soil. On the other hand, there are soils in which the water easily rises by capillarity, and also soils which hold fast water absorbed by them. When the sheet of water is at a small depth and the ground covering it of the former nature, the water may rise by capillarity to the level of the soil. The air circulating at the surface of the soil evaporates this water and there is thus established a kind of vertical current between the sheet of water and the surface Though the surface appears dry, the subsoil is moist and soft. If the surface is covered with an impervious wearing course, the action of the air is no longer felt, the water continues to rise until the soil is saturated and the earth becomes still softer.

In cold weather all these moist earths easily freeze to a great depth and then swell. When earth freezes water is attracted, as it were, by the ice crystals forming everywhere especially at the surface In the process of freezing land can absorb much more water near the surface and hold it in the shape of ice than it could absorb and hold under ordinary temperature conditions. Thawing begins at the surface As the water cannot escape through the subsoil which is still frozen, or clayey, stony or of some other impervious substance, it gathers, producing "soft spring spots" on a foundation of ice, clay, rock or generally impervious substance.

These spots, called by the farmers "ventre de Boeufs," are truly the plague of roads in this latitude. They are to be found everywhere. They occur every year at the same places, making roads dangerous until the end of June They even occur on improved roads at places where they did not previously exist. All earth should, therefore, be freed as completely as possible from subterranean moisture before a road becomes sufficiently resistant.

V-Drains and Cobbled Ditches.—Work, whose object is to free the soil from subterranean water and drain it, is called underdrainage. This underdrainage is done by means either of earthen or concrete pipes or of field stones. The object is to prevent water from rising in the soil by capillarity to less than 18 in. beneath the bottom of the foundation.

Drain pipes should be used only when springs are met with or when the surface of the subterannean water rises at times or remains continually at a small depth beneath the surface of the soil. This is ascertained by digging small wells to a depth of about 4 ft. If at the end of 24 hours, for instance, water is found there, the surface of this water marks the level of the subterannean sheet of water, and pipes should then be used. If no water appears and the earth is still moist and soft, it is the case previously mentioned of land absorbing and holding humidity. In such lands, which frequently contain soft, springy spots, pipes have little or no effect. Other means must be used. Generally, field stones are disposed in thick layers, serving at the same time as foundation, made in the shape of a V to economize stone and to drain the water, or else trenches filled with cobble stones are used. V-drains are frequently expensive on account of the large quantity of stones required. Drains made of trenches filled with cobble stones, when they are judiciously used, well laid and proportioned, give as good results in the long run and are less expensive.

Obviously, drying and underdraining the subsoil, while indispensable, are not always an easy task, and it may be said again that suitable results take much time to achieve unless the cost is incresed in order to obtain a quick result. However, it is drainage and underdrainage that should be first carried out in order to allow the soil to dry and settle before laying the wearing courses. The modern top courses are generally expensive, and it is neither recommended, nor even justifiable, to risk them when the substructure is not sufficiently dry or firm, even though there is a good foundation.

The progressive method of improving roads gives all the time necessary for a proper preparation of the sub-structures, and traffic hardens them. When the time comes for laying the foundations and top courses, the firmness of the soil on which they are to be laid is accurately known. It must always be borne in mind that undulations in the wearing courses which appear after a few years, are nearly always due to lack of firmness in the substructure, whatever the resistance of the foundations and the quality of the materials may be. Undulating surfaces with many depressions will be found even in wooden pavements resting on concrete foundations, due to the above cause.

Foundation One of the Most Important Things in Road-Making.—Foundations are classed among the permanent works because they have all the above-mentioned characteristics of such works. In laying foundations it must always be borne in mind that a permanent work is being done, and care should be taken to make it a durable one. Vehicle wheels must never reach them, and they must be thick and solid enough to prevent their being broken or crushed out of shape by the heaviest vehicles. This, unfortunately, has not always been understood, and there have been many disappointments, especially since heavy trucks have come into use. At present this is better known and receiving more attention. Without entering into the details of their construction, it is nevertheless useful to call attention to the following points of importance: Homogeneity and hygroscopicity. When stones of different sizes are used in making the foundations, the different sizes must be laid one upon the other in uniform layers, and they must not be made throughout their whole thickness of stones of the same size in one place and of another size in an adjacent place. Too much gravel, dust or sand must not be used at one place to fill voids and a smaller quantity in another location.

The best foundations are those made of uniform size throughout all their thickness and laid in a uniform manner. When stones from 4 to 6 in. in size are used, they must be of good quality, pressed solidly against one another by hard rolling so as to break the excessively thin corners and edges and to interlock them firmly. If the stones are unstable, too soft or alterable, the vibration caused by passing vehicles will wear them out at the points of contact, and, in the long run, the foundation will sink irregularly.

The stones must touch each other, and filling the voids with too much dust, sand or even gravel is another drawback, as the stones then will not touch; and in such a case the firmer particles have a tendency to drop and the larger pieces of stones to rise, at least in this climate, causing, in the long run, harmful movements and some kind of segregation in the foundation.

Foundations of coarse sand, not hygroscopic, where laid on clay soil, give good results under water-bound macadam, and are economical in places where stone is dear. Well-made telford foundations are excellent, but very expensive.

The concrete foundations are the best, but their cost is generally considered too high in the case of rural roads. They are subject to cracks in soil not dry or firm enough, especially on account of frost, and it frequently happens that the cracks rise to the top course.

In calculating the thickness of foundations, it is absolutely necessary to take the heavy weight of modern motor trucks into account.

Temporary Top Courses.—The temporary use of foundations covered with gravel as a wearing course allows of regular compacting by the traffic and of correcting their defects whenever they appear. When the regular wearing course is laid, their solidity and resistance are exactly known. The soft places have become hardened, and there is less likelihood of the defects which occur in wearing courses laid on an insufficiently firm foundation.

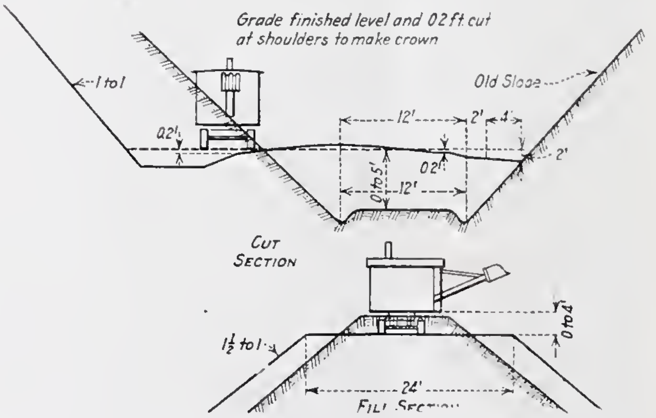
I may add also that, in this province, the rural roads are covered with snow during a portion of the year, and, consequently, the wearing of the top courses of the rural roads by traffic is much less than in countries where there is traffic throughout the year, and this may have much influence on their choice.

It would be advisable also to consider substituting one kind of top course for another, taking existing conditions in this province into account; also to consider what precautions should be adopted when laying cheap temporary top courses for avoiding certain expenses which otherwise would be incurred when it becomes necessary, owing to increase of traffic, to use them later on as foundations and to cover them by improved top courses.

Method of Converting Old Railroad Grade into a Highway

There are many miles of abandoned railway grades that could easily be made into highways. In Minnesota several jobs of this kind are now under way. The illustration, reproduced from Successful Methods, shows the methods used by S. J. Groves & Sons, Contractors, Minneapolis, in converting an abandoned railway grade near Alexandria, Minn., into a highway.

The cross section required by the Minnesota State Highway Commission called for 24 ft. width of roadway in cuts and ditches as the figure shows. The fills were to be 24 ft. wide on top. The method of widening cuts by filling and of widening fills by cutting is clearly shown. A steam shovel was used and was operated in the ditch in widening cuts and in the center of the fill in lowering fills.



Method of Making a Highway From Abandoned Railway Grade.

The fill required in cuts varied from 0 to 5 ft. The cut required on fills varied from 0 to 4 ft. A maximum grade of 2 per cent was secured. The completed road will have a good location and a well drained roadway obtained at a minimum cost.

Instructions of Arizona State Highway Department for Guidance of Its Engineers

Introduction.—While in the employ of the highway department you are expected in the first place to devote your entire time to the service of the state.

You are not only to prosecute your work with energy and intelligence, but also to win for this department the good will and co-operation of the people in any community in which you may be stationed. You should, therefore, see to it that public opinion is favorable insofar as strict attention to your work and a business-like and courteous manner on your part can form such an impression.

You are particulary cautioned against becoming a party in any local or political controversy.

The plans for any piece of work as submitted to you from the office of the state engineer should not be changed by you in the field without authority from this office. You should, moreover, request written instructions in case any such change is ordered in plans, specifications or contract.

Avoid making estimates in the field for the benefit or information of anyone outside of this office. Furnish all data of interest and information to this office alone. The state engineer reserves the right for himself to give publicity to any information deemed advisable.

All surveys, methods of procedure, reports, notes, plans, etc., should invariably be made in accordance with the standards and instructions of this office.

Instructions to Engineers on Reconnaissance Surveys.—Before going into the field, engineers undertaking a reconnoissance survey should obtain all camps available covering the region to be traversed and in particular any topographical sheets available of the United States Geological Survey.

When such maps are available a paper location of the proposed route may be made thereon prior to going into the field.

It is advantageous to provide township plats in surveyed land with the field notes accompanying the same to assist the engineer in identifying the section corners on the ground.

The equipment provided should include an aneroid barometer, a hand level, a pair of binoculars, a Brunton pocket transit, a pedometer, and a sketching tablet.

It is not practicable to give detailed instructions that will completely govern the selection of routes for highways. The following instructions must be regarded as incomplete and the locating engineer must often violate or disregard them. In such cases, the reason for any such disregard shall be definitely stated in the report submitted at the completion of the reconnaissance.

Make the total length of road between controlling points as short as possible.

Use gradients not greater than 5 per cent nor less than 0.2 per cent.

Avoid crossing drainage lines where practicable. Follow along tops of ridges as much as possible.

Locate road in good road building material where practicable.

Avoid sharp and excessive curvature. Sacrifice standard grade maximum for short distances where it is necessary to do so in order to preserve satisfactory alignment.

Provide for traffic a safe length of sight ahead along roadway on all curves.

Avoid grade crossings of railroads.

When practicable, without sacrificing more important considerations, follow along section lines.

Consider the interests of the local traffic and local property holders wherever it is practicable to do so.

Locate all gravel beds, sand pits and other road building material contiguous to the work.

Engineers on reconnaissance should at the completion of their work on any section transmit to this office a detailed report with hard copy sketch of the route selected, with all information obtained in relation to the same shown thereon.

Instructions to Engineers in Charge of Location Surveys.—Engineers undertaking location surveys should provide themselves with complete camp equipment and line wagon or light truck.

This equipment should include a transit, a level, two or more steel chain tapes 100 ft. long, two sighting poles, four plumbobs, etc., to level rods, three 50-ft. metallic tapes, six axes, black graphite marking crayons, pencils, note books, standard forms, etc.

All useful data of previous surveys in the vicinity shall be obtained. These shall include bench mark elevations, transit point ties, and the bearings of any tangents of adjoining surveys to which the work may be tied.

Preferably the party should consist of:

TRANSIT PARTY—
- 1 transitman.
- 1 flagman.
- 2 chainmen.
- 2 axmen.
- 1 stake marker.
- 1 combined cook and line wagon driver.

LEVEL PARTY—
- 1 levelman.
- 1 rodman.
- 2 tapemen.

The purpose of the survey is:

To select the most advantageous alignment of the proposed highway and to determine a proposed grade line thereon.

To furnish all information necessary concerning existing objects and conditions which will be needed by the office engineer in preparing plans and estimates for the proper construction of a highway and the necessary bridges and culverts along the surveyed line.

To furnish all information necessary in regard to property lines and property holders along the proposed highway.

To furnish cross section data sufficient to serve as the basis of accurate earthwork computations.

To so monument the line and to provide such reference points and bench marks that the constructing engineer may proceed without trouble or inconvenience.

In making the location survey the engineer is expected to be guided by the reconnaissance. In the event that an engineer finds good reason for departing substantially from the route determined upon in the reconnaissance survey he shall report his findings to the state engineer and await his instructions.

In making the location survey the same idea should govern as in the reconnaissance survey. In addition thereto the following instructions will apply:

Begin the survey at its westerly or southerly end so that when plotted from left to right the arrow will point to the top of the sheet or toward the right.

The survey will consist of a series of tangents and circular curves tangent thereto, except when the angle of deflection is 2° or less the circular curve may be omitted.

Consider 400 ft. as minimum radius in fairly open rolling country. Use no radius less than 200 ft. in length, except in heavy mountain country.

Provide for traffic a clear sight ahead of at least 300 ft., grading high points back where necessary to secure the same. In case this is impossible in heavy mountainous work provide for widening the roadway at such curves. Provide also for danger signs.

Set a stake at each 100 ft. station on center line of survey properly marked with its serial number, beginning with 0.00 at the initial point of survey. This stake may be of lath except at transit points and terminal points. A hub at least two inches square driven flush with the ground with tack on line shall be placed at each transit point and the two terminal points of survey. Such hubs shall have station number on a guard stake driven about 10 in. from center line.

Reference points shall be established about 40 ft. from the center line at initial and terminal points of survey and at many P. C. and P. T. points. The distance and position of such reference hubs shall be shown in the notes and such distance also marked on the guard stake driven beside the R. P. hub.

Tie the initial point of survey to the nearest section corner of public land survey where practicable.

When the survey starts from a point on a road already surveyed re-establish the tangent on such former survey, which passes through the Sta. 0.00 of the new line to be surveyed and measure the deflection angle between such old tangent and the new line tangent. Show the equation of station numbers and of bearings at such common point.

When it is practicable neither to tie to public land survey nor to any previous survey, the position of the initial point should be described as accurately as possible with reference to a town or railroad survey station nearby or a numbered pole of a power or telephone line or some well known and prominent natural object.

Note all intersections of center line with section lines and property lines. Show the station numbers of same and angle of intersection, and the distance to the nearest corner along such section line.

At the commencement of the survey take an observation on Polaris or on the sun and determine the true meridian at Sta. 0.00. Adjust the variation plate in the compass box so that transit needle will read all bearings referred to the true north. If line runs easterly or westerly it will be found that observations will show a convergence of about 40 seconds for a distance of one mile in longitude. The original meridian shall be used throughout the survey or equation of bearings recorded. The notes must show details of observation and amount of variation turned off on plate.

The circular curves shall be designated by the length of their radius. Their length shall be computed as the true length of the arc. This length may be obtained by multiplying the length of the corresponding arc of radius unity by the length of the given radius.

The bearing of each tangent shall be computed by means of the deflection angle from the previous tangent and the needle reading shall also be observed as a check on the computed bearing. Both shall be recorded and the deflection angle shall be doubled. Both single and double angle shall be recorded.

Immediately after the setting of each line needle and before the tape is removed from the ground additional points shall be marked with plus stakes where the level party is expected to take extra cross sections and the nearby topography shall be sketched by station numbers and offset. In case a culvert is desired at any station, a stake shall be set marked "Culvert."

The topography should show buildings, fences, brush, trees, pole lines, streams, railroads, etc.

Uupon reaching the foresight with the stationing and taping, its exact location shall be established and hub set and referenced. Where tangents are short in length at least one hub shall be referenced in each one thousand feet.

Detailed information shall be obtained at each stream crossing and large scale sketches prepared showing the topography at the proposed bridge site. The location of suitable sand, gravel, and water, shall be reported. Detailed cross sections of stream bed shall be taken on center line of survey and at each ten feet interval for thirty feet on both sides of the center line. Each reading should show the character of the material on which rod is held, whether rock, sand or clay. The highwater marks shall be accurately determined and show on each section. If the highwater marks cannot be determined it may be necessary to run out drainage areas. Test pits shall be dug and the results reported. Recommendations shall be made in regard to the depth of foundations and the size of openings required.

The level party shall first establish permanent benches from ten to twenty stations apart along the center line and about forty feet therefrom.

Determine elevation of bench mark near 0 + 00 referred to mean tidewater datum either by connection with a government or railroad bench or by aneroid barometer.

Run a line of check levels over the line of benches established, reading rod to one hundredth of a foot.

Run a combined line of profile levels along center line of survey and cross sections at right angles to the same. These cross section levels consist of readings referred to the same datum as profile levels and taken at every break in the cross section profile. These cross sections shall show elevations 30 to 40 ft. each way from center line.

These sections shall be taken on every 100 ft. station stake, at all transit points and all breaks in the profile on center line, and on every proposed culvert location.

Take profile center line readings at stations 100 ft., 200 ft., and 300 ft. back from station 0 + 00, and ahead beyond the end of the line. In solid rock cuts not less than four cross sections should be taken on every 100 ft. of center line. On existing bridges and culverts four or five sections shall be taken, these should be at the top and bottom of slope on both sides of stream.

Show on each cross section the taped distance from center line to edge of beaten track of any existing road, edge of stream or distance to fence line, pole line, tree line, railway line, or rock outcrop. Show top and bottom of any existing bridge or culvert openings and elevations of any bridge seat.

Read all ground surface shots to the nearest tenth of a foot. Read all turns to the nearest hundredth of a foot. Do not allow an error of more than three hundredths of a foot between benches.

In taking cross section, to avoid confusion a regular routine should be followed. The rodman and tapemen should first stand togther at stake on center line; the instrumentman should call the reading to the note keeper; the rodman should then proceed to the left carrying the end of the tape and rod, the tapeman holding tape on center line; the rodman selects the point and holds the rod; the instrumentman calls the rod reading and the tapeman calls the distance out and description of point wherever edge of road or solid rock or other description is needed.

The engineer in the field will prepare a map of center line on detail paper to a scale of 100 ft. 1 in., showing topography and any notes and information desirable. This map should be in the rough only, with notes and lettering written in with no attempt at lettering but merely as a check on the notes submitted. He shall also prepare a profile of the ground surface on center line to a horizontal scale of 100 ft. to 1 in., and a vertical scale line of 10 ft. to 1 in. This profile should be plotted up each night for the information and guidance of the locating engineer. He shall show on the same a recommended grade line and should note any portion of same not admitting of revision with the reasons therefor.

At the completion of the survey all notebooks and maps should be submitted to the general office in Phoenix, Ariz., where the plans, estimates, and specifications will be prepared.

Field Notes and Notebook.—Engineers in charge of location surveys and their assistants shall furnish the general office with complete and comprehensive notes showing all details of the survey made.

The first page of each notebook shall show the name of the route surveyed and the name of the engineer in charge of the work.

The second page shall show a complete table of contents.

At the beginning of each day's notes the date, the names of the members of the party, and the duties perfomed by each, and the weather conditions must be recorded.

The level books may be submitted to the general office before the surface elevations are computed from the rod readings shown but if computed must show by whom. The level notes must show, however, complete computation of the elevation of the bench marks, and table of same with description.

Office Work.—All tracings, cross section estimates, and specifications shall be made in conformity with the requirements of the U. S. Bureau of Public Roads.

Construction.—Engineers in charge of construction will be responsible for all purchases, expenditures for all pay rolls and for all engineering features of the work.

Standard forms will be provided for submitting weekly reports of the progress of the work and monthly estimates of the work done.

Engineers in charge of construction will make no changes in the plans or specifications except as authorized by the state engineer.

Their first duty on arrival on the work is to check the elevation of all bench marks and to retrace and check the alignment.

Folowing the completion of these checks on the work of the preliminary survey, construction engineers must make a complete detailed location survey with permanent stakes so that this survey shall serve also as a staking out for construction in conformity with the plans and specifications furnished by the State Engineer. The notes shall show completely all the details of such location in a manner similar to that used on location survey notes.

The stakes used on this staking out may consist of 12d nails with red cloth on the head driven on center line and heavy stakes offset about 30 ft. from center line. These heavy stakes may be cut wedge shaped about 30 in. long and must be driven to a firm bearing. Such heavy stakes must be set at all even stations, also at the beginning, end and each 50 ft. station additional around curves.

In making this location survey and construction layout an equation in the station numbers shall be introduced about every one thousand feet in order to make such station numbers conform to those of the location survey.

Cross sections shall be taken with one sight read to hundredths of a foot taken on the top of offset at every stake and station. These cross sections shall be plotted 5 ft. to the inch both horizontal and vertical.

A revised profile shall be laid and template showing proposed work shall be plotted on cross sections. The area of cut and fill shall then be determined by the use of the planimeter.

Each offset stake shall be marked with its station number, its offset distance to nearest tenth and the amount its top is above or below finished grade.

All transit points must be thoroughly referenced before construction begins.

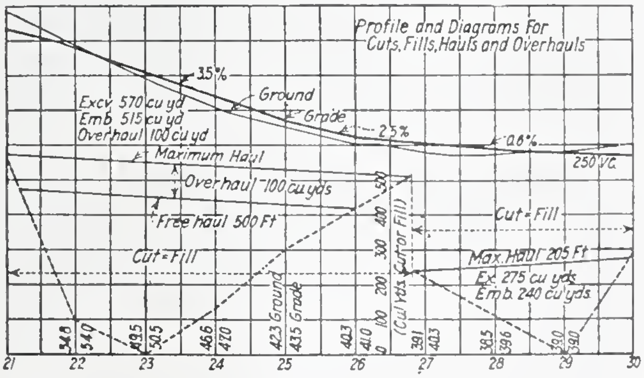
The construction engineer shall be responsible for all work done, for all directions given by the foreman on the work, for the purchase of all supplies, and for the good treatment and payment of all labor employed.

Simple Method of Computing Overhaul

An unusually simple method of computing overhaul is employed by the Minnesota State Highway Commission for its road work. The accompanying illustration and information from Successful Methods will make clear the method.

The dotted lines show the disposition to be made of the earth. Vertically, each of the larger squares represents 100 cu. yd. Horizontaly, each square measures 50 ft. of haul. The diagram was drawn by adding the fills and subtracting the cuts between successive stations and plotting the algebraic sum obtained at each station. This makes a diagram which slopes downward for cuts and upward for fills.

For example, at Station 21 there were 570 cu. yd. cut. At Station 22 there were 100 cu. yd. cut. The difference between these two quantities is 470, therefore the point is plotted to indicate 470 cu. yd. difference. Lines are drawn connecting all points.



Quantities Are Computed Separately for Each Section of Equal Excavation and Embankment.

Since it is necessary to have more cut than fill to allow for shrinkage, the cut end is higher than the fill end of the diagram. A line is now drawn connecting the high points of the curve. If this line is level the cut and fill balance, but no allowance is made for shrinkage of fill.

If the free haul is 500 ft., another line showing "Free Haul" is drawn parallel to the line above at such a point that it will intersect the curve and scale just 500 ft. in length. The perpendicular distance between these two lines will scale the amount of overhaul.

The free haul and the maximum haul are added and divided by 2. Subtract the free haul from this result and the overhaul distance is obtained.

Then, for example:

Overhaul distance		Overhaul yardage		Overhaul price		Amount due
(40 ft.)	×	(100)	×	(2 ct.)	—	($0.80)

This diagram besides showing the amount of overhaul, is very valuable in showing the contractor where to place the dirt in making cuts and fills.

Road Building in Full Swing.—Since early in 1919 there has been a steady increase each month in the Federal-aid business in the Bureau of Public Roads of the United States Department of Agriculture. States in all sections of the country are filling their projects and receiving allotments. The road-building era is in full swing, and it would seem that the end is not yet. All indications point to greater records in the months immediately to come.

The Duties of the County Highway Engineer-Manager*

By E. E. SOURS,
County Engineer, Mecosta County, Michigan

Many of the larger counties of the state have realized the value of a county highway engineer in the directing of their road building. Gradually some of the less wealthy counties through the example set by the more populous counties and through other influences, have hired highway engineers.

Now the law defining the status of future road commissioners has brought into being the superintendent of county roads. Who is better fitted to fill this position than a properly trained engineer? True, we may find competent engineers with very little executive ability, but a mind capable of an engineer's training will in the majority of cases have the other qualifications which go to make a leader.

At present there are 31 counties in Michigan employing county engineers on a salary. In general as the engineers have inspired confidence in the commissions of their ability to manage affairs, this work and authority have been gradually delegated to them.

The duties of an engineer, and we refer to those engineers who are acting more or less in the capacity of a county manager, might be grouped under four heads, loyalty to the profession, duty to his employer, his attitude toward the state and his attitude toward local road builders.

Honesty, ability and industry, there are other requisites for a county engineer, but unless he brings these with him to his work every day he is not loyal to his profession, to his employer, or to himself.

The road funds of the county are spent on the recommendation of the county engineer. It is a common criticism that public money is not spent wisely. In other words it is charged, and too often justly, that those entrusted with the expenditure of public money do not get as great results dollar for dollar, as does private enterprises under the same conditions. If the county engineer cannot do better work at less cost than the untrained man, the position of county engineer cannot be justified. It is up to the road engineer to produce results.

Essential Points for Securing Greatest Efficiency. Technically the work of the road engineer is the construction and maintenance of the county roads. How this can best be accomplished must be decided by the organization in each county. It might be well to mention in general some of the essential points which must be observed, if the greatest efficiency is to be secured.

To begin with there must be entire harmony between the engineer and his commission. To often the engineer makes the mistake of assuming a professional superiority over his associates, looking at all problems from a technical standpoint. The other fellow's viewpoint is always worth consideration, even if it is not based on mathematical hypothesis or engineering principles. There is always something to be learned; when an engineer ceases to be a student he is retrogressing. Use tact with your commission, use tact with your foreman, use tact with the public. The best engineering education will avail one little if he lacks tact and good judgment.

Some definite system must be followed. The work must be planned so that there are few mistakes and little lost motion.

Good judgment must be used in selecting subordinates. No matter how well plans are laid, if the ones to whom is entrusted the carrying out of those plans, is lazy, careless, or incapable, the efficiency of the system is impaired. Every principal is responsible for the actions of his agents. Managers and engineers cannot shift their responsibilities. It is therefore up to the engineer to select the best material available for helpers. Thousands of dollars have been squandered in this state on roads by incompetent foremen, because they could be hired cheaply. Money is well invested in a good foreman, while a poor foreman is expensive at any price.

County Engineer and Township Roads.—One may say that a county engineer's responsibility ends at the boundary of the county. But does it? The wideawake loyal engineer is larger than the county. That time is past when a local community is sufficient unto itself. The trunk line roads of the state are the main arteries of traffic and are fed by the county system and these again by the feeders in the township so that the whole is a comprehensive system of highway serving every community in the state. Yet while the counties and townships both are working on the same system, they often work at cross purposes instead of working hand in hand with one another, and with the state to complete this system. Local jealousies often defeat the interest of a community at large. The county and township organizations are often widely separated and fail to co-operate, often when it would be a mutual benefit. Probably due to the old method of building township roads, the township organizations sometimes are inclined to resent what they choose to term "interference in their local affairs by state and county officials." To the wide-awake engineer the law providing for the survey by county engineer of township roads may be made a means of making a closer relation between township, county and state. The county engineer is one of the important connecting links between the township and the state. A township commissioner is not unmindful of a little assistance from the engineer, and competent advice, tactfully given, will reap a harvest of better roads and better bridges.

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*Abstract of a paper presented at the last annual meeting of the Michigan Engineering Society.

Mecosta County Plan of Co-operative Road Building.—In this connection may be mentioned a co-operative plan which has been adopted by Mecosta County. As it is a pioneer move along this line it is worthy of consideration. It is not to be presumed that the authors anticipated all of its effects, its primary object being set forth in the preamble which reads:

Whereas, the early completion of the system of county trunk line roads which has heretofore been adopted by this board, would be of benefit and advantage to the people of this county, and

Whereas, it is represented to this board, first that the adoption of a fair and equitable plan which shall extend to each township substantial and reasonable aid toward the construction of roads, which are to constitute a part of the said county system of roads, and second, that the building of such roads, by the township or responsible individuals, at favorable times, and under favorable conditions, and through the help received from local subscriptions, can be done at less cost than if built by the board of county road commissioners by contract or days work.

Briefly the plan is as follows:

1. Any township, city, village or individual desiring to build a section of road on the county system, makes application to the county road commissioners for a survey and estimate of cost of construction of said parcel of road.

2. The county engineer makes the survey and estimate and submits the same to the applicant.

3. Such municipality or individual electing to construct such road may do so under the following conditions: From the engineer's estimate of cost, the estimated state reward is deducted. The township is paid 50 per cent of the balance and the state reward.

The first payment is 40 per cent of the engineer's estimated cost of building grade, which includes the culverts, and is paid when the grade is completed and accepted by the engineer.

The second payment is 40 per cent of the engineer's estimated cost of placing the first coat of gravel, and is paid upon the acceptance by the engineer of the first coat of gravel.

Final payment is made of the balance due on the road together with the state reward when the road has been accepted by the state highway department.

If the one proposing to build the road is satisfied with the estimate he files a request with the board to that effect. A contract is then entered into between the contractor and the board of county road commission. So far this plan is a source of satisfaction to its promoters. There has been application for survey and estimate of nearly every mile of unimproved road on the county road system. Approximately 14 miles have been completed or are under construction. The prospects for next year are very promising.

This plan, while its main object is the early completion of the county road system, without the necessity of a bond issue, at a minimum cost to the public, yet it has more far reaching effects, from the standpoint of the engineer.

It brings the townships and county road organizations in closer touch with one another, it admits of a closer supervision of the township roads by the county engineer, and tends to raise the standard of efficiency of the township commissioners.

Assuming that all of the townships accept the co-operative plan of building county roads, the township commissioners practically become county employes under the direct supervision of the county engineer. The commissioners will come to depend on the assistance of the engineer, thereby extending the engineer's influence over the construction of township roads. The benefit of this influence can be no better illustrated than in the case of bridges and culverts.

The commissioner builds the culverts on the county road, necessarily under contract according to standard culvert plans of the state highway department. The wide-awake commissioner appreciates the better results secured under the instruction of the county engineer and uses his education to advantage in his later work in the townships. The county engineer has an opportunity through these commissioners to carry on a campaign against poor concrete and drainage work. This practice of building poor culverts, often with insufficient capacity to accommodate the drainage areas, necessitates their rebuilding within a very few years. It is not only a detriment to the roads, but is an unnecessary bill of expense, thousands of dollars being expended each year in repairing washouts and rebuilding culverts.

While the engineer may not have enough time at his disposal to closely supervise the building of culverts in the township, the fact that he can refer the township authorities to standard plans, and can give the workmen some instruction in the building of foundations and the handling of concrete, is bound to produce better results, especially if he has improved every opportunity to inspire in township officials a confidence in his ability and to create a demand for his service through a desire to be helpful to the local road builders.

Ordinarily one township commissioner is not interested in what the commissioners in the neighboring townships are doing. Under the co-operative plan all commissioners being employes of the county and working to an estimate, are continually measuring their efficiency by the work of their fellow commissioners. And farther, interested individuals in a township are comparing the work of their commissioners with the work of the commissioners of neighboring townships.

The effect of these comparisons will tend to make the qualification of a road builder the controlling factor in the selection of the next commissioner which has not always been true in the past.

Not the least of a county engineer's duties, speaking in a broad sense, is the education of the road men of his county. The engineer may ask the old question, "Am I my brother's keeper?" Is the County Engineer interested in the township roads more than to comply with the letter of the law which provides for the survey of township roads by the county engineer. If he is all that the name implies, county highway engineer-manager, he has an interest in all roads in his county whether county or township roads. To get good roads you must have good road builders. It is true the State Highway Department and the University of Michigan are carrying on a campaign of education in road building, but it does not reach the majority of local road builders, nor does it go into details which is necessary to the foreman who is in direct charge of the work. The ordinary township commissioner as a rule has had very little, or no experience and instruction, in handling men to get the maximum results, or in laying out his work. He is handed a blueprint profile which is Greek to him and told to build a road. He has no instruction in its use except what he can glean in a few minutes conversation with a district engineer once in three or four months, or from some associate who has possibly had some experience along this line.

Largest County Road Bond Issue.—St. Louis County, Minnesota, by a vote of about 9 to 1, carried on July 1 a proposition for the issuance of road bonds to the amount of $7,500,000. This is the largest sum ever voted or set aside for road building by any county in the United States. The second largest was that of Dallas County, Texas, voted a few weeks ago, of $6,500,000.

Methods of Resurfacing Old Macadam*

By WILLIAM N. BOSLER,
Division Engineer, Department of Public Roads, Frankfort, Ky.

Perhaps the most general and perplexing problem met with today by highway engineers in Central Kentucky, is the resurfacing, economically, of an existing waterbound macadam road that is filled with ruts and holes. The condition most frequently met in practice is the road surface filled with ruts and pot holes, or the surface entirely worn off, which has been caused through internal wear, lack of sub-drainage, ditching or inferior grade of stone.

In Central Kentucky two types of macadam roads are met with—the old telford road and the waterbound macadam road.

Resurfacing Old Telford Macadam.—Years ago, when materials and labor were cheap, slaves were used in laying this telford type of construction. Today we find the cross section of this same telford road distorted almost beyond recognition and with practically no metal covering remaining. The road in question may be dished in the middle, concave in sections, the edges of the telford being as much as 6 or 8 in. higher than at the center. Again we find the telford wholly exposed with practically a flat or very little slope to the cross section remaining. This undoubtedly is due to inadequate sub-drainage or improper foundation and not to original design.

Being confronted with these conditions, and a limited road fund at hand, the road engineer is up against a tough proposition. In some rare instances it might pay for him to salvage the remaining telford, crush it with his portable crushing outfit, and use the stone thus derived in constructing a new waterbound macadam road. However, it is generally conceded that such a road would not be the equal of a resurfaced macadam on this existing telford foundation. Owing to the present cost of labor it would be prohibitive, in price, to attempt to re-lay the existing telford to its original cross section and then resurface as waterbound macadam. As a solution to this problem, it is the writer's opinion, that the old telford foundation should be left undisturbed except where it is above the new established grade and cross section, and a filling of creek gravel should be properly placed and spread on the old distorted telford. The builder should add enough gravel to produce a true cross section to the subbase course, then it should be properly spread and rolled with a 10-ton roller, allowance being made for sub-soil and blind drainage where necessary. Most localities have an abundance of good grade creek gravel, consisting of sand and gravel, which could be secured within reasonable hauling distance and thus reduce the cost of preparing the subbase.

The next operation consists in spreading and rolling, on the sub-base just prepared, crushed stone not to exceed 5 in., compacted measurement. After this screenings are spread and rolled, watered and re-rolled until the surface is properly bound as a waterbound macadam road surface.

The spreading and rolling and watering of crushed stone and screenings on this type of resurface work is just as important and should be done in the same way as in constructing an original waterbound macadam road. In some exceptional cases a small amount of surfacing metal is still remaining as a covering on the telford foundation. However, it is too thin to bear consideration and if the telford is true or nearly true to cross section our best plan is not to disturb the existing metal or telford, but simply to add crushed stone not to exceed 5 in., compacted measurement, spread properly, rolled thoroughly, apply screenings, water and bond as a waterbound macadam road.

Resurfacing Waterbound Macadam.—Our first duty is to ascertain what the existing macadam road consists of: how much metal remains and in what condition it is. This information cannot be obtained entirely by a mere surface inspection, but requires digging into the old road metal. It is true we can see at a glance where the grade has been disturbed, where the cross section has been destroyed, but to arrive at the amount of metal remaining in the road it is absolutely necessary to make test holes or test trenches. Either method will procure information. However the trench method; that is, digging a trench, say 12 in. wide to the full depth of metal, across the entire road, at right angles with the center line of the road, gives the best results. These test trenches should be taken every 100 ft. or so, depending upon the general condition of the road. This will enable one to see just where the road has worn and how much.

Having arrived at the conclusion of how much metal remains and in what condition it is, the next duty is to establish an economic grade line. Bearing in mind that most any practical road builder can construct a road with 12 in. or more of stone, it is the road engineer's job to determine what will be a sufficient amount of metal to add, and no more, to insure thorough bonding with the existing metal and produce a good road surface. Most authorities agree that 7 in. of compacted crushed stone is ample for any waterbound macadam road. In other words, there is a limit beyond which depth of stone in resurfacing work is too expensive for results obtained, and beyond that limit it is better and cheaper to surface or otherwise resurface the road in question.

Now having determined the amount and condition of existing road metal and having established an economic grade line, it is our duty to salvage or prepare existing road metal for the new stone. As an illustration, say, the road in question has 3 in. or less of compacted metal remaining and is filled with ruts and holes. In that event it is practically useless to scarify it, as scarifying would tend to destroy the bonded metal already in place and would not help our cause any. Oftentimes scarifying is misused, and as a result you disturb what structure you had to start with, and in the end you are endeavoring to bond by rolling in one operation, a greater depth of metal than can be properly handled. The better plan would be carefully to fill all ruts and pot holes with clean stone well graded and thoroughly roll it. Add sufficient metal to insure 7 in. of compacted stone, spread to true cross section, rolling it thoroughly with 10-ton roller. Add screenings, roll, dry, then wet and re-roll until the whole is thoroughly bonded and presents a smooth surface.

For next consideration, take a macadam road filled with ruts and holes that has 4 in. or more of compacted metal, the road being distorted as to cross section. Our first operation is to fill the holes and ruts in question with new metal, then spike and scarify the road. After which harrow and grade the existing metal to the true cross section and roll thoroughly with 10-ton roller. Now add sufficient new stone to insure 7 in. of compacted metal, considering the amount of stone already in the road. Spread and roll with 10-ton roller, add sufficient screenings, roll it dry, then wet and re-roll until the whole is completely bonded and presents a smooth surface.

In some cases one might find a macadam road of 7 in., or more, compacted metal that is filled with holes and ruts, but has retained its cross section approximately and is true to line and grade. In that event it is the writer's opinion that it is useless and expensive to add an arbitrary amount of new stone. The proper course to pursue would be to fill the holes and ruts with well-graded crushed stone. Spike, scarify, and harrow them, adding just sufficient new metal to bring the road to its proper cross section after shaping. Roll thoroughly with 10-ton roller, applying sufficient screenings which when properly wet and rolled will bond thoroughly and produce a smooth surface.

In this day of inadequate road funds a road engineer that can work existing macadam road that is filled with ruts and holes, utilizing every ton of stone remaining in it, and adding just as little new stone as is absolutely necessary to produce a well-bonded road of smooth surface, has indeed accomplished something that is a credit to himself and his county.

Resurfacing or reconstruction of waterbound macadam roads, under present day traffic conditions, presents problems worthy of the attention of highway engineers. These problems are of vast importance, and should be given more earnest consideration than they have received in the past if we wish to make our road funds cover a greater mileage.

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[*] From a paper presented at the 1919 Road Builders' Week of the University of Kentucky.

Street Flusher Has Speaking Tube.—The motor street flushers of the city of San Francisco are equipped with a speaking tube by means of which the operator at the rear of the truck communicates with the driver. The operator's seat also is surrounded by a heavy iron fender which protects him from being bumped by other vehicles.

Land Platting in Michigan

In a paper presented at the last annual meeting of the Michigan Engineering Society, Mr. Harry L. Brightman gave a concise statement of the general requirements for recording plats according to the laws of Michigan, together with observations from the standpoint of the owner, the engineer and the officials who handle assessments. An abstract of the paper follows.

The reason for having a platting law is, of course, to make the transfer and recording of property easier, the assessment and collection of taxes more simple, than would otherwise be the case. In the early days of platting in Michigan, the requirements were few and simple, for the placing of a plat or sub-division on record. Of late years there have been numerous laws enacted for raising the requirements, and for the purpose of eliminating some of the defects that heretofore existed. At present the requirements of our State law for recording a plat or sub-division is as follows:

In making the survey it is required that permanent monuments shall be located in the ground at all angles in the boundaries of the land platted and at all the intersections of streets or streets and alleys as shown on the map or plat, and when there are permanent objects in the vicinity of such monuments the bearings and distances of such objects shall be noted. The character and dimensions of the monuments and the bearings and distances of such witness points or objects shall be distinctly given in the most convenient manner on the plat. The exact position of the monuments should be indicated on the plat by a small circle "O" or cross "X" and such monuments must be of metal not less than ½ inch in diameter and 15 in. in length.

If the plat be of a town, city or village, the full name of such town, city or village must appear as the title or name of the plat; or the land platted, be an addition to or a subdivision of a town, city or village already platted, then let the title of the plat include, with the name of such addition or sub-division, the name of the town, city or village, as the case may be, of which such platted land is a subdivision, or to which it is an addition. The name of the county in which the plan platted is situated should appear under the title.

The plat must be on a scale showing not more than 200 ft. to an inch, and on good muslin-backed paper, 18x24 in. in size; all certificates must be written or printed on the paper on which the plat is made, and on the same side of the sheet.

The sections and parts of sections platted must be designated by lines with appropriate letters and figures. In case of a subdivision of lots or blocks of a previous survey, the outlines of the original or previous lots or blocks so subdivided must be designated by lines, which must be marked with appropriate letters and figures. This must be done in such a manner as to show, without reference to the written description the starting point and the course and length of each of the outlines. Where any of the outlines are identical and coterminous with the lines of a previous survey or plat, it will be sufficient to give the designation of such outlines as given in such previous survey or plat.

The land platted is to be fully described in writing or printing upon the paper on which the plat is drawn. This description must be so complete that from it, without reference to the plat, the starting point can be determined and the outlines run. In connection with the description should be a short and simple form of dedication, which must be signed by the proprietors and their wives, whose signatures must be witnessed, and whose execution of the dedication must be acknowledged as deeds conveying land are required to be witnessed and acknowledged.

There must be drawn upon the plat a plain designation of the cardinal points and a correct scale.

Where all the lots in any block have the same dimensions, it shall be sufficient to mark the precise length and width upon one tier thereof, but all gores, triangles, or other lots, which are not either squares or parallelograms, shall have the length of their sides defined by figures.

The streets must be named or numbered and their course and width designated. All public grounds and alleys must be properly designated.

The surveyor must certify that the plat is a correct one and that the monuments described in it have been platted as therein described.

Detached parcels cannot be included in one plat, nor can more than one plat be made on one sheet. Contiguous parcels owned by different parties may be embraced in one plat, all joining in the execution and acknowledgment; it is not necessary to specify the particular parcels belonging to each.

Before a plat shall be forwarded for approval, and before any copies are made therefrom there must be attached to or inscribed upon the original the County Treasurer's tax certificate required by law. Also a certificate of approval of the city or village council, or township board, as the location of land platted may require and the certificate of approval of a majority of the county board, consisting of the Judge of Probate, County Clerk and County Treasurer, or by a majority of the County Board of Auditors in counties having such boards.

For the purpose of approval and recording, an exact copy is to be made from the original, after certificates above referred to are inscribed thereon, and said original and copy forwarded to the Auditor General of State for approval and record, together with $4.00 fee required by the statute. When the original plat has been approved by the Auditor General the same will be forwarded from the Auditor General's Department to the Register of Deeds of the county in which the plat is located, for recording, together with fee required by statute, while a copy will be filed in the office of the Auditor General. Should proprietor wish to retain a copy, two copies of the original should be forwarded at the time of forwarding the original plat, one copy of which may be made on tracing linen, if so desired, which second copy will be returned to proprietor with proper certificate thereon.

Almost all large cities now require streets to be graded before a plat is accepted or approved and it is becoming the rule of the townships as well, to require more or less grading of streets before the Township Board accepts the plat, and the maintenance of the streets contained therein. This requirement has developed a situation where proprietors wish to avoid the expense of grading streets, refuse to place their plats on record, selling the lots off by metes and bounds, and merely allowing their streets to become public highways by user. This often works a hardship on uninformed persons purchasing lots in such a subdivision, when, after a few years, a number of houses are built along certain streets, the people therein apply for water mains and sewers, and often for special drainage relief. Proprietors who take this method of selling their land are usually uninformed as to common requirements for drainage, etc., and very often break every law of good land platting. Their main idea being to get as many lots as possible, to make all streets narrow, and to put in very few cross streets.

When a plat is presented to a Township Board, there are sometimes instances where the township officials wish to have street locations changed or further grading work carried on, and being unable to agree with the proprietor, have not approved of a proposed plat. In one instance a plat was not approved by a Township Board for the reason that the proprietors would not obtain an under crossing from a railroad to allow storm water to flow away. The proprietors to get around this, undertook to dispose of their plat in the following manner: They dedicated the street to the State of Michigan and sold a total of 220 lots off by metes and bounds, without going into the question as to whether the street was properly located, or as to whether the drainage should have been taken care of at that time, it would seem to me that there should be a remedy, and, while I am not thoroughly informed as to this procedure as worked out in one or two instances in Europe, I believe such a system has been worked out.

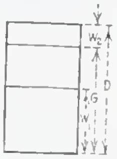
In seeking a remedy for the present hit or miss system of making additions to our cities and villages, and to overcome somewhat the illogical layouts with regard to direction of travel, storm water drainage, sewerage systems, etc., we find ourselves lined up with a score of other large questions, or propositions which are not being properly met under existing conditions by our own cities. Our Common Council and Commission forms of government are good, but do not go far enough. They change too often, and, even with the help of a City Manager, are unable to meet and plan for work that requires a number of years for its completion.

It is my opinion that all cities and growing villages should have a "City Planning Body," or committee of a permanent nature, with executive authority, to make plans for the city that will ultimately merge into a complete whole. Their duties would cover acquirement and operation of parks, a general paving, sewer, water supply and sewage disposal program, street widening, elimination of railroad crossings, new additions, boulevards, and many other things that require a term of years for their accomplishment. At present our Council or Commission elected for a term of two years hardly get into harness before they are replaced, and if an attempt is made to start anything that requires more than one year to complete, the chances are that the next Commission or Council turns the program upside down. As a consequence our public building and street plans are built piecemeal and usually without regard to future connections and requirements.

Go into any City Engineer's office and you will find plans of prospective work outlined far in advance of what he expects his governing body to approve. If once in a while the Council does approve, work started and plans made to continue the same, the next Council, elected on a reform or money saving platform, stops the work.

Land plats properly come under the head of City Planning and a city planning body of a permanent nature should be a part of each city's organization, and in the case of populous counties a similar body should have control of all public plans and work

Pail Test for Voids in Gravel; and Sacks of Cement in Concrete



The following simple test for determining the percentage of voids in ground or broken stone has been used to a considerable extent in the Southwest: Take an empty pail, lard can or other container, with vertical sides, and measure its inside depth (D). Fill about half full of water and measure the water depth (W). Fill with gravel until the pail is just even full of water and measure the depth of the water (W) above the gravel: $D - W_2 = G$.

Then for gravel or crushed rock: $\text{Voids} = \dfrac{W_1 - W_2}{G}$

The following tabulation shows the number of sacks of cement per cubic yard of concrete:

Mix.	Voids. 45 per cent or less.	Voids. 40 per cent or less.	Voids. 30 per cent or less.
1:4.8	3.4	3.2	3.0
1:3:6	4.4	4.2	3.8
1:2½:5	5.2	5.0	4.5
1:2:4	6.3	6.0	5.5
1:2:3	7.2	7.0	6.5
1:1½:3	8.0	7.6	6.8
1:1:2	11.0	10.5	9.7
1:1:1	14.0	13.6	12.8

The number of sacks of cement required for various lengths of concrete pavement can be ascertained as follows:

Width of pavement = W.
Length of section = L.
Center thickness = C.
Thickness of edges = E

Average thickness, for curved crowning, $\dfrac{2C + E}{3} = T$

Cubic yards per section $= \dfrac{W\,L\,T}{27}$

Sacks per section $= \dfrac{W\,L\,T}{27} \times$ sacks in table given above.

Example: Section 18 ft. x 40 ft., 7 in. and 5 in. thick, 1.2.3 mix with 40 per cent gravel,

$$\frac{18\text{ ft.} \times 40\text{ ft.} \times 527\text{ ft.} + 7.0}{27} = 98\text{ sacks}$$

The above information is taken from a sheet of the Oklahoma County Highway Engineers' Pocket Book. It was compiled by H. V. Hinckley, consulting civil engineer, Oklahoma City, Okla.

State Road Maintenance in Maine.—During 1918 the Maine State Highway Commission had 4,250 miles of road under constant daily patrol from April to November, 480 patrolmen being employed for this work. The total expenditure was about $600,000, of which the cities and towns paid $200,000, the state paying the balance.

How the Local Engineering Society Can Be of Service to the Public*

By WILLIAM S. WOLLNER

When the employes of a public utility go on strike the decision as to whether their demands should be allowed does not rest with the utility nor with the strikers, but with the public. This is well understood by students of industrial economics who have watched the public utility pass from its role of a privilege-granted corporation, doing business primarily for the profit of its stockholders, into a franchise governed industry doing business as a public service utility service being the primary object of the utility; a fair profit to the owners being requisite in order to obtain the necessary capital, the rate of profit being in ratio to the need and quality of the service.

If a utility is giving reasonable service with a reasonable profit to its owners its public obligation may be said to be "balanced." But if it decreases its service and earns an undue profit, or if it increases its service and decreases its profit its public obligation immediately becomes "unbalanced." Service as used in this connection, must be measured by its cost as well as by its actual standard of excellence. Assuming the service rendered by a public utility of any kind and its return to its owners as being balanced at the time when its employes strike for increased compensation or decreased hours of service, any or all three things may result from compliance with the strikers' demands either service to the public will be decreased, rates to the public will increase, or returns to the owners will decrease It is therefore wise that the final decision as to whether the demands of the strikers shall be granted shall depend upon public sentiment.

Sentiment may be the result of sympathy with the strikers living or working conditions; it may be influenced by excellent service or lack of service by the utility, or by any one of a dozen other things. Sentiment engendered by sympathies of this kind undoubtedly influences the settlement of strikes but this cannot always be justified by economic considerations; and it is economic consideration, or the balance of public obligation, that should be the ruling consideration in the settlement of issues raised by strikes of employes of public utilities Unfortunately, the public does not usually take the economic phase of the matter into consideration at all and swings its influence in accordance with its sympathies with or against the employes or the utility.

It is here that the engineer may step in and by giving the benefit of his trained ability to the public cause, assist in making the judgment of the public conform to the facts of the case. It is obviously impossible for a single engineer to undertake a task of this kind but it is not at all unreasonable to assume that the American Association of Engineers through its chapters, may interest itself in work of this nature and through its position influence the public toward sober judgment based on economic truths. With engineers in its membership trained in all branches of public utility service, and with valuation experts and engineering accountants there is no problem of this nature that could not be accurately solved by the American Association of Engineers and it is certain that in no other way could the association better fulfill its public function.

As an example of how the American Association of Engineers might function in a case of this kind we will take the case of the employes of a telephone company who recently struck for increases of pay for operators and mechanics The territory served by this utility covers several states and the strike of its employes entirely demoralized service in some places, greatly reducing service where it was not entirely demoralized.

Public sympathy immediately swung to the side of the operators and was principally evidenced by action upon the part of social service workers who rallied to the aid of their striking sisters and through publicity and other means endeavored to influence the telephone company's management to grant the girls' demands. The establishment of canteens for feeding the strikers was another evidence of the trend of public sympathy, as was the demand for immediate resumption of service. It is undoubtedly true that the living conditions made necessary by the wages paid operators fully warranted this action, but the point that appeals to the practical engineer is that there was absolutely no consideration given to the necessity or otherwise of increasing rates, decreasing service, or decreasing return to owners if the demands of the employes were granted.

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*From the September issue of The Monad

In order to give the public the facts to which they were entitled so that they might determine whether it was or was not necessary to provide additional revenue or to decrease service in order to comply with the public obligation to the corporation, an engineering investigation should have included: (a) a financial history of the company and its present ownership, (b) a study of operating conditions, (c) a financial study. It is assumed that the utility corporation wishing to secure its portion of public sympathy, and to obtain the necessary increase in rates if this increase was needed to meet the strikers' demands, would fully co-operate with the investigators. Failure to co-operate, if given the publicity it would deserve, would certainly indicate to the public that it was necessary for the corporation to conceal facts that it should have in order to pass unbiased judgment upon the company's ability to meet the demands. Failing to receive assistance from the corporation, the investigators would still have the records of the public utility commissions and other public bodies to which to go and which should in any case be used to the greatest extent possible.

The manner in which the investigation should be conducted and the facts that should be produced would quite naturally be decided upon by the committee making the investigation, but in general the following outline would govern in a case such as the one under consideration. The ownership study should disclose whether the profit or loss resulting from the operation of the utility is spread over a large or small territory, both as to geographic consideration and number of persons. If possible it should be determined whether the profit or loss is shouldered by persons or corporations who are well able to absorb a decrease or increase in them, or whether the stock ownership rests largely in the hands of investors and others who must depend upon the return they receive for their actual livelihood. It should not be overlooked, however, that in any case it is unfair to expect capital to finance utilities from which they do not receive an adequate financial return.

The service study should deal largely with its sufficiency or insufficiency prior to the strike. This study should take into consideration the various classes of service and it will probably be found that some classes have been overserved while there is room for improvement in the service given other classes. In any case the report of the investigators should clearly set forth recommendations for improvement or reduction in service. The financial investigation should show the operating results with reference to both invested capital and physical valuation of the property.

Upon completing its report the committee should present it to a meeting of the chapter, specially called to consider it, and the entire contents should be made the subject of discussion and mature consideration. When the chapter is satisfied that the report is in final shape for submission it should be given the widest possible publicity. The public would thus be placed in possession of the facts that should enable it to determine whether the economic conditions under which the company is working warrant an increase in wages without a corresponding increase in rates. It would then remain only for the public to determine whether it was willing to meet this increased cost, whether it preferred to accept decreased service, or whether it preferred to leave wages as they were.

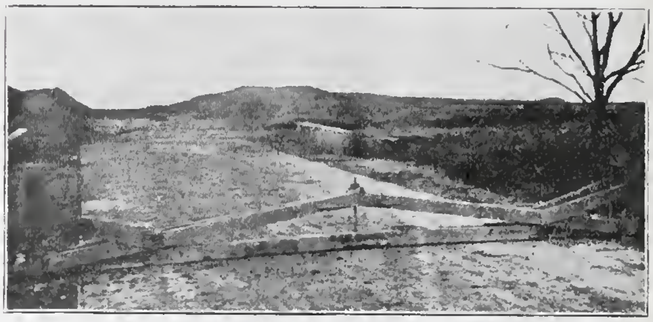
Government Commission Investigating Rates of Pay of Municipal Employes.—The Joint Commission on Reclassification of Salaries, created by the 65th Congress is instructed to investigate the rates of compensation paid to civilian employes by the municipal government and other government establishments in the District of Columbia, and is now engaged in making a preliminary classification. The Washington Chapter of the American Association of Engineers is securing information relative to the salaries of technical men included within the scope of the investigation the commission is authorized to make, and making recommendations as to the revisions which should be made. The actual preparation of the commission's report is being made by Arthur Young & Co., Efficiency Engineers.

Practical Method of Constructing Superelevated Curves on Concrete Roads

An efficient way of getting the superelevation on curves is described in the August Concrete Highway Magazine by John W. Graham.

An "A" frame strikeboard was used and the desired crown was obtained by adjusting a nut on the upper end of a ¾ in. bolt, which extended from the apex of the strikeboard frame down to the face of the board. Only 5 or 6 lineal feet of the concrete were struck at a time, after which the nut was tightened or loosened slightly before the board was advanced a similar distance.

The strikeboard was built of three straight 2 by 6 in. yellow pine plank, bolted together, and an A frame of double lines of 2 by 6 in. plank, securely anchored at the ends of the board and rising about three feet at the center. This construction was rigid enough to produce a striking edge of sufficient strength and heavy enough to hold itself on the side forms. A graceful crown and easy riding surface were obtained by simply adjusting the elevation of the striking edge as just described.



Adjustable Template Especially Adapted to Striking Off the Concrete in the Warped Sections.

Highway Engineering Courses at University of Michigan

The Board of Regents of the University of Michigan has created a professorship of highway engineering. Professor Arthur H. Blanchard, late of Columbia University, has been appointed to this position. Funds were also provided for the appointment of an assistant professor of highway engineering who will have charge of the highway laboratory and courses in design, laboratory and field work. This position will be filled by the appointment of John H. Bateman, B.C.E., a graduate of the University of Michigan and for the past four years assistant engineer and engineer of the Michigan State Highway Commission. The regents have made liberal appropriations for equipment, current expense and for the salary of clerical and laboratory assistants. The University of Michigan four years ago commenced to develop work in highway engineering and the work in the university laboratories has been built up to a good state of efficiency under Professor John J. Cox, who recently resigned to devote his whole time to construction work. A large program of work under Professor Blanchard will include the continuation of all work formerly given undergraduate students in highway engineering, together with one or two new courses, the addition of courses in highway transport and highway economics, the development of graduate work during the regular collegiate year and the continuation of the highway short course which has been given at Michigan University for the past five years. In addition to this work special courses for graduate practicing engineers leading to the master of science in engineering degree will be given during the winter months. These courses will be given intensively so that engineers who can only take a few months away from their practice may take the work and secure credit towards the degree.

Classification of Engineering Positions in State, County and City Service

The state and municipal section of Engineering Council's committee on the classification and compensation of engineers has sent a questionnaire to all state engineers and to all city engineers in cities of 100,000 population and over, asking information as to the compensation paid July 1, 1915, and July 1, 1919, and the compensation recommended. Accompanying the questionnaire is the tentative classification of engineering positions reprinted below. This classification follows the general plan adopted by the full committee to facilitate comparison of engineering services, and was worked out in detail by the section committee in co-operation with a special committee of the Municipal Engineers' Society of New York City.

CLASSIFICATION OF ENGINEERING POSITIONS IN STATE, COUNTY AND MUNICIPAL SERVICE.

Title.	General Description of Position.	Duties.	Qualification
Consulting Engineer.	On special duty of responsible character requiring special qualifications and initiative.	Giving expert advice on engineering work of the most important character, involving critical examination and report on questions of cost, design, specifications, construction, maintenance, operation or engineering policy.	Such training in civil, mechanical, electrical, sanitary or other engineering branches as is evidenced by a professional degree granted on the completion of a standard course of instruction in an engineering school of recognized standing, with experience of not less than four years in the duties of Engineer and broad experience in the branch of engineering involved in the work concerned. If a professional degree has not been granted by an engineering school of recognized standing, an engineering experience of not less than fifteen years may be considered to qualify for this position provided that the record of work performed gives substantial evidence of an engineering knowledge and ability of the highest order.
Chief Engineer, State Engineer, City Engineer, Deputy Chief Engineer, Deputy State Engineer, Deputy City Engineer.	Chief administrative officer having full charge of organization including determination of policy.	Assuming entire responsibility as the engineering executive for reports, estimates of cost, design, specifications, construction, maintenance or operation of engineering works or projects either that are to be constructed or are to be operated.	Such training in civil, mechanical, electrical, sanitary or other engineering branches as is evidenced by a professional degree granted on the completion of a standard course of instruction in an engineering school of recognized standing, with experience of not less than four years in the duties of Engineer and broad experience in the branch of engineering involved in the work concerned. If a professional degree has not been granted by an engineering school of recognized standing, an engineering experience of not less than fifteen years may be considered to qualify for this position, provided that the record of work performed gives substantial evidence of an engineering knowledge and ability of the highest order.
Engineer.	Chief of major subdivision in responsible charge of large unit.	Supervising work requiring executive ability. Furnishing expert or critical engineering advice of a high order for executive action.	Such training in civil, mechanical, electrical, sanitary or other engineering branches as is evidenced by a professional degree granted on the completion of a standard course of instruction in an engineering school of recognized standing, with experience of not less than three years in the duties of Senior Assistant Engineer. There may be substituted for a professional degree such training in engineering as would qualify the incumbent to properly perform the duties of this position.
Senior Assistant Engineer.	Chief of intermediate subdivision in responsible charge.	Exercising independent engineering judgment and assuming responsibility in studies and computations necessary to preparation of plans, designs, reports, etc. Supervising work of small units in engineering organization.	Such training in civil, mechanical, electrical, sanitary or other engineering branches as is evidenced by a professional degree granted on the completion of a standard course of instruction in an engineering school of recognized standing, with experience of not less than two years in the duties of Assistant Engineer. There may be substituted for a professional degree such training in engineering as would qualify the incumbent to properly perform the duties of this position.
Assistant Engineer.	Chief of minor subdivision.	Taking charge of design, surveys, or construction work involving considerable responsibility on small engineering projects or minor work on large projects.	Such training in civil, mechanical, electrical, sanitary or other engineering branches as is evidenced by a professional degree granted on the completion of a standard course of instruction in an engineering school of recognized standing, with experience of not less than one year in the duties of Junior Assistant Engineer. There may be substituted for a professional degree such training in engineering as would qualify the incumbent to properly perform the duties of this position.
Junior Assistant Engineer.	On general duty under direction, but requiring special education and training and the use of initiative and originality.	Using surveying, measuring and drafting instruments, engineering tables and diagrams. Computing and compiling data for designs, reports and records. Inspecting or investigating minor details of engineering work and materials. Keeping notes of field work.	Such training in civil, mechanical, electrical, sanitary or other engineering branches as is evidenced by a professional degree granted on the completion of a standard course of instruction in an engineering school of recognized standing, but not necessarily any experience in the practice of engineering, other than that which is incident to the attaining of such qualifications. There may be substituted for a professional degree such training in engineering as would qualify the incumbent to properly perform the duties of this position and would be a suitable foundation for the advancement of the incumbent to higher positions in the professional engineering service with further training in engineering.
Senior Draftsman.	On general duty under direction but requiring special education and training and the use of initiative and originality.	Directing work of a drafting squad. Supervising preparation of maps, plans, etc.	
Draftsman.	On subordinate duty requiring special education or training but not requiring special originality.	Preparing general working drawings where design is furnished. Plotting of notes and preparation of maps. Design of simple structures. Making computations and compiling data for reports, records, etc. Checking plans, surveys, etc.	
Junior Draftsman.	On subordinate duty not requiring special education, training or originality.	Tracing and lettering maps and plans. Making simple drawings from sketches and data. Making minor calculations.	
Chief Instrumentman.	On general duty under direction but requiring special education and training and the use of initiative and originality.	Directing work of field party on surveys or construction. Keeping notes, record of work, etc. Supervising construction or repair work. Directing and leading in the work of computing surveys, estimates, etc.	
Instrumentman.	On subordinate duty requiring special education or training but not requiring special originality.	Running surveying instruments and adjusting and caring for same. Computing surveys, estimates, etc. Inspecting incidentally construction or repair work.	
Rodman.	On subordinate duty not requiring special education, training or originality.	Running tape or leveling rod. Performing other miscellaneous subordinate duties in survey party in field or office, as directed.	

Maintenance of Macadam and Gravel Roads*

By R. C. HEATH,
Road Engineer, Kentucky State Department of Public Roads.

The building of surfaced roads has been carried on in Kentucky for nearly 100 years. The important main highways were practically all built either by the state or by the toll companies. The bulk of the road building within recent years has consisted of rebuilding and relocating these old highways to accommodate modern travel. It was, to say the least, unfortunate for the counties that the toll roads were freed and the automobile was made serviceable at about the same time. And, by the same token, it was certainly a bit of luck for the companies.

It is not out of place to bring out right here the point that the county officials are not to be too harshly blamed for the failure to maintain the highways. Practically all the heaviest traveled highways were tool roads and the counties, therefore, had no need of spending much money or maintaining an organization for maintenance of the relatively lightly traveled roads which were under their care. When the roads were freed, new responsibilities were thrown upon the officials. A new vehicle terribly destructive to road surfaces was coming into use and no increased funds were given them to care for the roads; in fact, in most counties, the road fund has not been increased up to this day. The result of this situation is that Kentucky, one of the pioneers in good road building in the whole country, instead of reaping the benefits of the enlightened progressive policy of the past is actually handicapped to a greater extent than the states which are just commencing to build roads.

Many of the roads were poorly located when built, but the country has developed so much that any relocation is out of the question on account of expense and damage to private property. Large areas which were formerly heavily forested are now cleared and under cultivation. This condition makes necessary many additional drainage structures as well as increases in the size of old ones. The steep grades have become more objectionable because of increased damage by water. All these things heavily increase the costs of maintenance.

The problem of maintenance in Kentucky today is to keep the roads in a passable, usable condition until the people realize the true situation and will give their officials the money to put the roads in first-class shape. It is impossible, with the present funds available, to attempt to install an efficient, scientific maintenance organization, such as is operated in New York, Pennsylvania or Massachusetts. The average man has no idea of what it costs to keep the highways of the states mentioned above in good condition. I believe that the present system may be saved from serious damage for a time with the present funds, but the roads will not withstand the present traffic very long and will deteriorate rapidly as traffic increases. This discussion is intended to suggest methods by which the present funds may be expended to save the roads so that when money is available there will be something left upon which to build.

Water is the worst enemy of the highway in this state; even the automobile yields in destructiveness to the sudden heavy rains which often last for several days with no letup. The most important maintenance work is the opening of ditches to prevent water from crossing or running lengthwise of the road surface. In many cases, it would be economy to construct ditches just back of the tops of slopes in cuts to prevent filling of the roadside ditches. The excess material removed from the ditches should always be hauled away and not cast out on the slopes. This increases the cost, but is well worth the money.

Every road should be ditched twice a year; late in the fall and early in the spring. It is essential that the ditches be straight and of uniform grade. Wherever possible, waterways should be cut to turn the water from the ditch. Culverts should be kept clean and the inlet and outlet ditches should be free from obstructions at all times. Very few highways have a sufficient number of culverts. Strictly speaking, building culverts is not maintenance, but the construction of a needed culvert frequently prevents serious damage to the road surface. Improving drainage is absolutely the first step in maintaining the highways and must take precedence over any other work.

Gravel roads in Kentucky have been built in almost every conceivable way, with and without specifications, rolled and travel-compacted, thin and thick, narrow and wide, and all kinds of materials have been used—bank gravel, creek gravel of every variety, river gravel and some material called gravel by courtesy only. The real secret of success with any gravel road is the ability to keep just enough moisture in the road. Too much water is no worse than too little. The surfaces of gravel roads can be kept in first-class condition under reasonable traffic by dragging. Dragging is an art in itself and requires excellent judgment. The road man must know from experience when the surface is in the right condition to drag, how much crown is best for the surfacing material, and above all must be willing to make several trips over the road rather than to try to get the result all at once. Slipshod or unskilled men mean wasted money and no results. More depends upon the execution of the work and the experience of the men than upon the methods used.

The roadway should be kept uniform in cross-section from ditch to ditch not only to prevent water damage, but also to distribute the travel so as to eliminate ruts. Concentrated travel on one section of the surface will soon wear out a gravel road. If gravel roads are well cared for they will withstand a great deal of steel-tired traffic. Automobile travel during the dry summer months when dragging is useless, and in fact harmful, will soon tear a gravel road to pieces. Many roads built of gravel are now being subjected to fairly heavy automobile traffic. It is out of the question to resurface with a higher type of road, because of the cost.

Most of these roads are built where good stone is not locally available and in fact where gravel is almost the only material at hand. These roads, therefore, must continue as gravel roads for many years to come and must be subjected to an increasing automobile traffic. The problem is, then: How are they to be maintained until a more suitable road can be built? The only answer is "surface treatment." The kind of material to be used depends upon the character of the gravel, the local conditions and the funds available. Every road is a distinct problem in itself and no general recommendations should be made to cover all road conditions. The fact is evident, however, that the surface must be held together by some kind of surface treatment. To save the gravel roads already built requires constant patrol by skilled men, study and experiment with different kinds of materials, and protection of the surface with the proper kinds of binders, when subjected to automobile travel.

The macadam roads in this state, like the gravel roads, have been built in many different ways and of varying grades of stone. The only road building rock in Kentucky is limestone, most of which is rather soft but possessed of high cementing value. This stone wears out quickly, but rarely does one see a road ravel. The water-bound macadam on roads in this state has withstood the automobile traffic wonderfully—if a hard stone had been used, the roads would have disintegrated very rapidly under such traffic. The cementing value of the stone is of great advantage in maintenance and this quality means a great saving on such work.

As a general proposition, there is plenty of material still in place on the old macadam pikes. Many of these roads were built with Telford foundations and investigation will show that those without this foundation have from 5 to 15 in. of metal in the roadbed. It is very seldom that one sees a pike where the surface has broken through the metal into the subgrade. The principal trouble with these roads is the poor cross-section and the rough, uneven surface with many pot-holes. By the use of a comparatively small amount of new metal for patching ruts and holes, and by surface treatment, these pikes can be made satisfactory for several years to come at much less than the cost of resurfacing. Great care must be exercised in selecting the material to be used on the surface and study must be made of the present traffic and its probable rate of increase.

The day is undoubtedly coming when higher types of roads must be built, but what Kentucky needs now is a larger mileage of surfaced roads rather than a smaller mileage of perfect highways. Unfortunately, there is not enough money available to rebuild all the old roads at once, and we must save these old pikes until we have the price of new ones. By means of careful patch-work, constant patrolling of the roads and surface treatment, it is possible and not too expensive to save the old roads. As money becomes available, resurfacing can be carried on and eventually everyone will have a good road right at his front door.

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*From a paper presented at the 1919 "Road Builders' Week" of the University of Kentucky.

Maintenance is a new proposition in Kentucky and if it is to be a success, it must be handled right. The people will never allow the old pikes to disappear for lack of care and neither will they pay for resurfacing the same old road every three years. If the road officials will maintain the old roads and gradually extend the higher type of mileage as money becomes available, the people will become educated to the necessity of high cost roads, but it requires more than the mere say-so of a road engineer to convince the average taxpayer that he should vote for roads that cost $20,000 a mile. The best way to gain the confidence of the average citizen is to care for the old roads so well and so cheaply that he cannot help noticing it. Good maintenance is its own best advertisement. If given half a chance, the old roads can carry for some time to come many a wagon and many a truck or automobile.

Cost of Digging Road Ditches

A considerable portion of the road work in New Trier Township, Ill., in 1918 consisted in the digging of new road ditches and the cleaning out of old ditches. For this work a special gang was employed under a foreman selected because of his ability to handle men and to do the engineering incident to drainage work. This foreman was paid $100 per month. During the month of July, 1918, the gang completed 18,621 lin. ft. of ditching, at an average cost of 6.74 ct. per lineal foot. The work required the moving of 3,121½ cu. yd. of dirt, the average cost per cubic yard being 40.47 ct. The following table from the report of H. H. Sherer, Township Highway Commissioner, gives the detailed cost of the work for the above month:

Date, July, 1918.	Number of men.	Man hours, 50 ct. per hr.	Total cost.	For'l number of feet ditched.	Cost per foot.	Cross-sectional area. Sq. ft.	Cubic yards.	Cost per cu. yd.	Remarks
1	4	36	$18.00	400	$0.0450	3.8	56.2	$0.320	Loam and clay soil. Part cleaning average of 5 in. dig
2	6	43	21.50	401	0.0502	3.7	56.1	0.383	Part cleaning, mostly new ditching. Loam soil
3	8	71.5	35.75	492	0.0726	4.0	67.4	0.530	Almost new ditching, depth 2 ft. Clay soil.
5	8	54	27.50	376	0.0718	6.1	85.0	0.318	Almost new ditching, depth 2 ft. Clay soil.
6	8	71	35.50	700	0.0507	5.8	150.3	0.236	Part cleaning depth 1 ft. Fairly easy dig
8	8	72	36.00	714	0.0504	5.9	155.9	0.231	Cleaning, 1 ft. digging. Straightening old ditch
9	8	72	36.00	790	0.0455	2.5	73.2	0.491	Cleaning, 1 ft. digging. Straightening old ditch
10	8	72	36.00	1,980	0.0260	1.6	81.7	0.390	Slight cleaning, loam soil. New ditching, 50 ft
11	8	72	36.00	175	0.0758	5.7	100.3	0.359	Almost new ditching, depth 2½ ft. Sticky clay.
12	8	72	36.00	625	0.0576	5.0	115.6	0.312	About ½ new ditching, depth 1½-2 ft. Loam soil
13	12	108	54.00	930	0.0580	4.2	144.6	0.374	About ½ new ditching, depth 1½ ft. Put in 3 culvert
15	12	108	54.00	617	0.0875	6.8	155.3	0.348	512 ft. partly new ditch. 75 ft. new ditch. Placed
16	12	108	54.00	385	0.1402	9.1	129.8	0.416	New digging, depth 3 ft. Clay soil
17	12	108	54.00	570	0.0940	9.0	184.0	0.294	Mostly new digging, depth 2½-2¾ ft. Clay and lo
18	12	104	52.00	718	0.0721	7.5	199.4	0.261	Half new ditching. Cleaning. Placed 1 culvert
19	12	108	54.00	796	0.0678	5.1	150.3	0.359	Clay material, wet and sticky. Digging 1½ ft.
20	12	18	9.00	112	0.0808	4.0	16.5	0.545	Mostly a good cleaning, digging about 1 ft.
20	12	90	45.00	545	0.0825	2.4	41.7	1.000	Straightening. Digging 6 in. x 6 ft. Cutting weeds
22	12	108	54.00	1,040	0.0519	2.2	86.2	0.626	Straightening. Digging 6 in. x 6 ft. Cutting weeds
23	12	108	54.00	1,090	0.0495	3.5	141.3	0.382	Shaping and cleaning. Easy digging, depth 1 ft. Loam
24	12	84	42.00	765	0.0548	4.0	165.1	0.254	Shaping and cleaning. Easy digging, depth 1 ft. Lo
24	12	24	12.00	230	0.0521	4.0	34.0	0.353	Extra care taken because of slight fall. Cleaning
25	12	102	51.00	1,220	0.0418	4.1	185.2	0.275	Extra care taken. Hard sticky digging
26	12	102	51.00	576	0.0885	5.0	106.6	0.307	Interrupted by rain. Sticky, clay soil
27	12	108	54.00	990	0.0545	4.2	154.0	0.350	Depth 2 ft. Clay soil. Removed brush
29	11	22	11.00	160	0.0687	5.1	30.2	0.367	Hard, sticky digging.
29	11	77	37.50	648	0.0573	3.0	54.0	0.695	Cleaning and shaping. Clay and loam soil
30	10	90	45.00	472	0.0953	7.0	122.3	0.368	Practically new ditching. Hard loam soil
31	10	90	45.00	404	0.1113	5.1	76.3	0.590	New ditching. Hard, clay soil. Depth 3 ft.

Finding Trucks' Effect on Roads. To determine the destructive effect of heavily loaded auto trucks on highways and streets, and to meet the demand for data on the design of road surfaces and foundations to withstand such heavy traffic, a series of experiments is being conducted by the Bureau of Public Roads, United States Department of Agriculture, at the Arlington Experimental Farm to determine the impact of auto trucks on roads. The most striking single development in the highway field in 1918 was the tremendous increase in motor truck traffic. Five years ago heavy motor trucks were few in number and limited practically entirely to the paved streets of larger cities. These vehicles now comprise probably 4 to 5 per cent of the grand total of all motor vehicles and are to be found wherever traffic conditions permit profitable use. But very few roads were designed to carry any large volume of this class of traffic. Consequently, the cost of adequate maintenance was increased greatly during the year. In many places the damage due to the incessant pounding of these fast and heavy vehicles was so great as to require complete reconstruction.

Council of National Defense Report on High Cost of Living

The United States Council of National Defense through Secretary Baker as chairman of the council has submitted to the President and members of Congress a full report on the concomitants of the high cost of living as surveyed by its Reconstruction Research Division—this in order that various agencies charged with consideration of this problem may take concerted remedial action.

The findings of the council indicate that the high cost of living is primarily due to curtailment in the production of nearly all commodities except raw food products, to hoarding of storage food products, to profiteering, conscious and unconscious, and to inflation of circulating credit, and that the situation may be most advantageously met by stimulated production; the repression of hoarding and profiteering, the improvement and standardization of methods and facilities for distributing and marketing goods, and the perfecting of means of keeping the nation informed regarding probable national requirements and current production and stocks.

The findings particularly emphasize the fact that high standards of living cannot be maintained upon any basis of reduced production.

The report says, in part:

The problem of the high cost of living is so interrelated with other reconstruction problems that the opening of this problem is tantamount to opening up the question of reconstruction practically in its entirety.

An analysis of the high cost of living problem brings out the following facts and principles as constituting the essence of the situation:

The only complaints of the high cost of living which have justification are those which are based upon inability of present income to maintain previous or reasonable standards of living at present prices.

America's industrial and economic achievements during the war, notwithstanding depleted man power and diversion of productive effort to war purposes, demonstrate the ample ability of the nation to sustain its population according to a standard of living equal to or above standards of living which obtained previous to or during the war.

The fundamental basis for the maintenance of national standards of living is adequate production, economical distribution and fair apportionment among the various economic groups which constitute our society. With the exception of agricultural activity, production since the armistice has shown evidence of curtailment, and has in general been abnormally low. Normal consumption cannot continue unless an adequate rate of production is maintained.

Food production and the facilities for food production were improved rather than injured during the war. Moreover, the program with respect to food production since the signing of the armistice has been one of vigorous expansion of the means of providing raw food products.

The number of cattle slaughtered in the period, January to May, 1919, was 3,803,000, as against 4,204,000 for the corresponding period of 1918, though the national reserve of cattle on farms had increased during the war. The situation in regard to swine is similar.

The production of civilian cloths and clothing has suffered heavy curtailment for many months since the signing of the armistice.

Boot and shoe production for civilian use has likewise undergone extreme curtailment since the signing of the armistice.

Housing facilties, due to curtailment, for many months following the armistice, of the production of building material and of building construction, is still far below normal. Rents continue to rise.

The first half of 1919 shows diminished production of raw materials and subnormal construction of new capital, and this indicates failure to utilize an adequate proportion of our productive forces in the preliminary processes of provision to meet future requirements. In fact, due to busines uncertainty and hesitation and tendencies to disagreement between productive groups, there ensued after the armistice a disuse of a large proportion of America's productive capacity. Unless this slump in production is atoned for by consistent future activity, and unless production is constantly maintained on an adequate scale, reduced standards of living will become inescapable, regardless of prices.

The very fact that prices of finished commodities, consumption goods so-called, have risen to an extent out of proportion to the rise in prices of raw materials and perhaps out of proportion to the rise in general wages, indicates that production carried on under these conditions is, in general, yielding profits abnormally high.

The Deficiency of Commodities.—The report emphasizes the fact that the deficiency of commodities, as compared with the volume of circulating credit and also as compared with living requirements, has survived the duration of the war, and the only safe and practicable method of effecting a readjustment now is by the practice of genuine economy, by increased production of the things society needs, and by curtailment in the consumption of those luxuries which larger money incomes have falsely led us to believe that we could afford.

It does seem not safe or practicable to initiate readjustment of prices by a premature reduction of credit for essential purposes, inasmuch as the first effect of contraction of such credit would be reduced production—the intensification of the fundamental cause from which the country now suffers. On the other hand, it is quite possible by increased production to create such a volume of commodities and wealth that the balance between physical goods and circulating medium will be normal.

It will not be overlooked, of course, that any movement to reduce prices otherwise than by the elimination of waste, the repression of profiteering and the stimulation of production may tend to bring on, as an indirect consequence, an increase of reduced production.

Adequacy of Supply. When a people finds itself compelled to reduce its standards of living because of inability to secure adequate quantities of the means of life, the first matter to be investigated is the question of the adequacy of the general supply, and the second question should be addressed to the matter of the apportionment of the supply among the various members, groups and classes of society. It is obvious that means of life cannot be plentiful unless production is adequate and there is therefore a plentiful supply available for such distribution.

While the close of the war found America tending to run short of clothing and housing, and behind in its program of highways and transportation facilities, it is a remarkable truth that we passed through the war period with a general tendency toward considerable increase in our production of foods. It is also true that we were under the necessity of supplying large quantities of food to our Allies; but we nevertheless, thanks to a magnificent agricultural program, came out of the war without serious shortage of food supply.

The wheat crop for 1918 amounted to 917,000,000 bus., as compared to an average for 1910-14 of 728,000,000; and the probable harvest in 1919 is 1,236,000,000 bus. Our supply of wheat in elevators and mills on May 9, 1919, was 96,000,000 bus., as against 34,000,000 bus. the year before. Notwithstanding large exports, our wheat and flour supply is obviously adequate, while the situation with respect to the other cereals is generally very good.

Though the sugar stocks are somewhat low in the United States, the future is normally provided for.

America emerged from the war producing meat at a rate far above pre-war figures, and yet possesses in reserve a larger number of animals on the farms than we had before the heavy war drafts upon our supplies began.

The report of goods in cold storage shows an increase in the quantity held on July 1, 1919, as against the same date a year ago. Taken in connection with the evidence of relatively abundant reserves of live animals and large crops for the current year, it would seem that some relief from high prices of food should be possible.

Present food prices are not to be accounted for largely on the basis of heavy exports. Exports of pork and beef, canned, fresh and pickled, for example, have been less for 1919 than in the previous year, the total amounting to 1,090,000,000 lb. in 1919 as against 1,122,000,000 lb. for the corresponding period of 1918—less than the amount of all meats in cold storage on July 1, 1919, which was 1,336,000,000.

It is true that food is, by comparison, plentiful. But it is also true that money or other circulating medium is unprecedentedly plentiful.

The Wool Situation.—The most obvious explanation of the high prices of woolens is the glaring fact of the extreme reduction in output which ensued after the signing of the armistice and the completion of army orders, which practically ended in January, 1919.

The war came to an end with the supply of civilian woolens unprecedentedly low. The total quantity of wool available for civilian fabrics between April and November, 1918, was probably somewhere in the neighborhood of 75,000,000 lb.—an amount perhaps a little more than sufficient to meet the demands of normal manufacture for civilian consumption for 1½ months. Yet, notwithstanding the fact of the general shortage of goods, the total consumption of wool in manufacture during the first 5 months of the present year amounted to but little more than one-half the amount consumed during the corresponding months of the previous year.

Cotton Situation.—When the war ended the world's cotton supply was below normal. The supplies of cotton goods were also low. The acreage planted to cotton was this year approximately 9 per cent less than for 1918. The present prospects are that the cotton crop will be small. Notwithstanding the release of labor, if it were needed, by demobilization, and notwithstanding adequate supplies of raw cotton to meet the season's requirements and the lack of any important difficulties in the way of reconversion to peacetime products, and with low supplies of finished goods in stock, the cotton industry kept more spindles idle during the first five months of 1919 than were idle during the corresponding period for 1918.

The Boot and Shoe Industry.—The production of boots and shoes for the first quarter of 1919 was reported as about 60 per cent below the production for the last quarter of 1918. Plants were practically closed and in some cases it is reported that machinery was returned to the shoe machinery company. In all, there were 75,000,000 less pairs of shoes produced in the first quarter of 1919 than in the last quarter of 1918. A reduction in the output of military shoes was, of course, to be expected, but in spite of the fact that soldiers would be expected to turn to civilian footwear, the census report shows a reduction of more than 25 per cent in the output of civilian men's shoes in the quarter ending March, 1918, as compared with the production in the quarter ending December, 1918. A reduction of between 25 and 30 per cent was also apparent in the output of women's shoes. The reduction in the output of shoes for youths, boys and misses was even more marked.

Housing and Rents.—It has been estimated that the United States was short 1,000,000 homes at the end of the war. A campaign to stimulate and encourage increased building was begun soon after the end of the war and carried on during the first half of the present year, and the national need of increased building became thoroughly advertised. In the meantime, however, those industries whose activity is a prerequisite to building, such, for example, as brick making, lime, cement and lumber production, remained relatively stagnant or tied up with price and labor disputes until late in the spring. The production of raw materials necessary in building construction was far below normal throughout the armistice period. Many plants were operating on part time and some were closed down entirely. Glass production was reported to be on a 50 per cent basis as late as May. In response to the building campaign and the recognition of the general need, and also, no doubt, in anticipation of handsome prices rendered obtainable by the acute shortage of housing, a fairly large building program was eventually gotten under way, and it is now experiencing handicap by reason of the shortage of building material which throughout the winter was obviously impending. The period of high and increasing rents and of high and ascending prices of houses appears, therefore, to be fairly certain of continuing for some time to come.

Railroad Construction, Traffic and Rates.—As stated above, the high cost of living really means shortage of the things we live upon. A comparison of railroad fright revenues seems to indicate that we are subsisting with a reduced use of freight service—and since we are not likely, upon investigation, to find ourselves growing more self-sufficing since the war, it seems that in receiving and sending less freight we merely find ourselves confronted with another evidence of the fact that we are in general consuming and producing less goods.

The Coal Situation.—The example of coal production furnishes another instance of the fact that America was able with depleted manpower and in the face of other handicaps during the war to set herself an example of increasing output such as she has not demonstrated the ability or disposition to parallel in the returning times of peace. The total amount of coal produced up to July 5, 1919, was 261,000,000 tons, as compared with 364,000,000 long tons for the corresponding period of 1918.

Iron and Steel.—The record of our after-war steel and iron output furnishes us with another warning that we have been neglecting to keep pace with the established American rate of industrial improvement and expansion and foresighted preparation for future requirements and progress.

The iron and steel business was considerably stimulated by war-time requirements. There was a governmental agency whose business it was to foresee the war needs, and to place orders so that those productive forces which are wrapped up in the steel industry might be utilized to capacity. For want of some industrial administrative insight which might utilize our maximum productive power the steel industry's activity has since the armistice greatly declined.

A survey points to evidence of a national loss of many billions of dollars worth of wealth, resulting from reduced production during a few months of the present year. Consider, for example, the forfeit implied in the failure to produce 75,000,000 pairs of footwear which could have been produced during the first three months of 1919. Calculate the significance of the reduction of over 100,000,000 long tons in the production of coal up to July, 1919.

Lack of Co-ordination.—When one contemplates the billions which have thus been lost through lack of co-ordination of our productive powers, one is moved to appreciate the urgent need of some local agency through which might be promptly and regularly secured and disseminated a knowledge of all of the important facts of our economic life and progress—requirements, rates of production, stocks on hand and prices—in manner similar, for example, to the official collection and announcement of information which is now being effected with regard to the slaughter of animals, the tanning of hides and skins, and the amounts in stock and in transit. It is beyond question that lack of real information gives rise to the major portion of the unnumbered industrial uncertainties, hesitations, misunderstandings and conflicts which constitute the chief interference with the realization of the highest potential economic welfare of the American people.

State Highway Construction in Maine.—During the period 1914-19, the Maine State Highway Commission built 390.8 miles of state highway at a total cost of $3,231,563. From 1908 to 1919 1,393⅓ miles of state aid road were built at a cost to towns and state of $6,063,123. The present mileage of state aid road is approximately 3,000, and the mileage of state highways is 1,400. The total road mileage of the state is 25,530.

Contracts—A Comparison of "Cost Plus" with Other Forms*

By ERNEST WILDER CLARKE

The use during the past two years of the "cost plus" form of contract on very large and complicated construction work seems to the writer to render the time opportune for a general discussion of the advantages and disadvantages of this type of contract.

In order to bring the matter before the society, the following résumé of some of the more or less self-evident faults and virtues of the usual contract forms are presented not with the idea of informing the members of the society but to establish a basis for discussion.

The usual methods of paying for work are by lump-sum, by item charges, and by cost plus a percentage. Under the first two methods, the contractor takes the engineers' or architects' specifications and estimates of the quantities, possibly checks the latter by his own computation, guesses at the interpretation which will be placed by the owner's representatives on the terms of the specifications and, from his knowledge of cost of materials and cost of labor, makes up a bid.

In a lump-sum contract the preliminary estimate of quantities is final, as are also the original plans of foundations, details, etc. Any changes must be a matter of settlement between the owner and the contractor. The latter takes all the gamble, and if conditions or quantities turn out more favorably than was anticipated, he wins; otherwise, he loses or is tempted to decrease the cost to himself by some method which generally means a poorer grade of work than that contemplated in the specifications. If conditions turn out much worse than anticipated by the contractor, he may forfeit whatever bond he put up and leave the owner and bondsman to settle. The owner very often desires to change the plans as the work progresses, either to cheapen the job or to add new features or improvements, and as there is no basis in the contract for payment to the contractor for such changes, a new bargain must be made. Generally, it is almost impossible to let additional work to a new contractor, so the owner is at the mercy of the original one and must submit to whatever terms he offers or forego the changes. The lump-sum contract has all the seeds of misunderstandings, disputes, lawsuits, and poor work; and not even the benefit of a pre-knowledge of ultimate cost, as there is almost invariably a long list of "extras."

In "item" contracts, the award is made on the sum of the products of the units in each item multiplied by the bid per unit. In most engineering work, the preliminary estimate of unit quantities is necessarily approximate; often the owner is unwilling on account of cost or unable for various reasons to make the investigations which would afford a basis for an exact determination. This is especially true of sub-surface structures, but quantities even in superstructures cannot always be accurately computed in advance. This is one of the great sources of disappointment to the owner in the ultimate cost of work let under this form of contract—of gambling on the part of the contractor and of loss or unfair cost to both.

The contractor and the owner may disagree on the interpretation of the data for the estimate; the contractor backs his judgment by bidding low on items which he thinks are over-estimated and high on those which are under-estimated. His total bid is lower than he would be willing to take the work for if the preliminary estimate of quantities was known to show also the final estimate, but allows a fair or better profit if the final estimate approximates that made by himself. In other words, the owner thinks he is letting the work to cost one sum, and the contractor expects to receive another and larger sum. Badly unbalanced bids are often thrown out, but a skillful bidder does not make his unbalancing so raw as to justify this action. This kind of bidding is not, per se, unfair or dishonest, and the ability thus to bid safely may be truly a part of the contractor's equipment, but it results in disappointment to the owner when he finds his final estimate largely in excess of that anticipated. If, on the other hand, such bidding is merely a wild guess or due to optimism on the part of the contractor, it i gamble pure and simple which, if unsuccessful, results in loss to himself and often to the owner.

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*A paper presented Sept. 3 before the American Society of Civil Engineers and printed in the Proceedings, Vol. XLV, No. 6, pp. 143-149.

Item bids require as a basis a set of definitions. Some items are so self-evident that no confusion can possibly arise as to the meaning of the definition; others shade into other items, and it is hard to define the line of demarcation. Other items are described as containing certain materials in certain proportions, and any variation from these proportions constitutes a new item, more or less expensive. Another item is described as being a certain stock material or machine, and any variation ordered or permitted raises the question of cost to the contractor. The possibility and even probability of argument and variation in cost, due to varied reading of definitions or changes in details of items, could be elaborated almost indefinitely, but enough has been said to illustrate how fruitful of bills for extra cost this part of the specification can be.

The "item" contract is better than the lump-sum in that changes in plan, due to the development of the work or the meeting of unforeseen conditions and variations in unit quantities, can be adjusted under the terms of the original contract, if the items included in that contract can be reasonably construed to apply to the new conditions; but it is still limited by the items which can be so construed and which both the contractor and owner are willing to admit are fair as to cost under these new conditions.

Applying to both these forms are several factors which are taken into account in their bids by all successful contractors and for which all owners pay indirectly. Some of these are the clauses removing responsibility from the owner for the accuracy of the preliminary data; for errors in laying out work; for refusing to accept the action of the owners' inspectors at the time of actual construction and retaining the right of rejection to the final inspection; making the owner's engineer the final interpreter of his own specification and allowing him to supplement his drawings and specification in any way, in order to make the meaning conform to this interpretation. The contractor has to take the gamble that the original data are reasonably accurate, that the work of laying out will be carefully done, or else maintain an engineering organization to check the work—for which duplicate organization the owner will pay—that the engineers will be just, and that the original engineer will remain in charge throughout the life of the work.

Many specifications require tests of material which, if rigidly enforced, would often cause great delay and expense to the contractor or the carrying of a large stock, entailing interest charges, storage space, rehandling, and other expenses. The contractor usually expects that the purchase of material from well-known manufacturers or certificates from them will avoid the enforcement of these clauses, but if he is wise, he considers the possibility that they may be insisted on, and bids accordingly.

In short, the tendency of the entire specifications is to remove responsibility from the owner and his representatives and place it on the contractor; also, all the gamble on weather, foundations, changes in labor and material market, and every other unknown or unknowable factor is carefully unloaded on him.

The contractor accepts all this, but the owner pays. The individual owner may save money, because the gamble went against the contractor on his job, but his neighbor loses, because in the long run the contractor must make money to live. The owner may lose by a contractor being too optimistic, getting a job partly done and then being unable to finish on account of high costs; re-advertising, re-letting, and delays follow, or else the bondsmen finish the work at a loss to themselves, which loss is passed on to other owners.

If a contractor makes an unexpectedly large profit, however, on Job A, he does not reduce his bid on Job B, in consequence, so that it is only the losses that are passed on to other owners and never the gains.

In "cost plus" contracts, the owner accepts all risks, all costs, and receives the benefit of all favorable conditions; each job carries its own load only, without the addition of losses on other jobs and without the percentage added by the contractor to offset possibly unfavorable conditions, ambiguous specifications, or captious owners.

The specifications and plans may be as general or as specific as the owner desires; changes can be made, difficulties met, and advantage taken by the owner of special machines, material and methods.

The contractor furnishes the plant, organization, and expert knowledge of construction and buying; the owner supervises the work and pays the bills.

In the case of "cost plus" contracts, the contract and not the specifications is the crux of the matter from both the owner's and contractor's viewpoint, but the writing of the contract is more simple than the writing of the specifications. It is necessary first to define what expenses are to be borne by the contractor, as not part of any one job. These may be head office expenses, salaries of chief officers whose time is spent only in part on the job, traveling expenses, except as agreed on, the contractor's auditor's, timekeepers, or material checkers. Second, to define what expenses are to be borne by the owner and are to form the basis for the fee. Such expenses would include the cost of materials purchased through the contractor, the cost of labor of all grades, and the cost of rental of plant. Third, to define what expenses are to be borne by the owner, but which are not to be included in calculating the fee to the contractor. These might be engineering services, inspection, owner's timekeepers and auditors, and the cost of specified material which the owner elects to purchase and deliver to the contractor.

The approval of the owner would be required for all purchases of material both as to the necessity for the purchase and the price paid. The owner may reserve the right to enter the market with the contractor, purchase any material he can buy cheaper than the contractor, and deduct such cost from the total cost of the work for fee calculation. The owner would have control of the number, grade and wages of all classes of labor, and, of course, would pay all insurance charges.

The sliding percentage with maximum fee, as used on government work, could be applied to any contract, large or small.

Contracts could be let on the basis of fee demanded, both percentage and maximum, on the size, adaptability and condition of the plant controlled by the bidder, and on his experience, reputation and the size and character of his organization.

It is true that the interest of the owner to keep down the cost, and that of the contractor to receive a large fee, would clash, but that is controlled by the sliding percentage which can be arranged to give an actually larger fee for smaller total cost, and by the maximum fee which is based on the owner's estimate of total cost.

Capable, honest, efficient contractors would fare well under this form of contract; the opposite kind would soon find it impossible to secure work. Engineers of the two classes would meet the same fate as the corresponding contractors. The engineer would no longer be supposed to act as an arbiter when he is paid by one of the parties to the contract to supervise the work of the other and to secure work conforming to specifications and plans which he himself has drawn. The engineer is always biased, and no matter how hard he tries to be fair or how cordial the relation between himself and the contractor, in case of argument, the latter bears the burden of the proof. For this state of affairs the owner pays, and the successful contractor is one who has added enough to his bid, in one way or another, to make up for the losses he suffers due, not to the work itself, but to the specifications. The writer believes that, given the same men as owner, engineer and contractor, a cheaper and better job can be secured by the owner, and, in the long run, more profitable business to the contractor by the "cost plus" contract than by either the lump-sum or item bids. The owner will not be confronted by bills for extras, vexatious claims for adjustment due to different interpretation of the specifications, lawsuits with their attendant cost, and the perpetual chance that, in spite of inspection, poor work will be done by the contractor in order to secure a profit on an underbid item. The contractor will be sure of a reasonable return on his investment in plant, he will not have to pay for special plant of use to him only on that one job, or to carry the burden of the gamble on unknown or unknowable factors.

The gamble belongs to the owner who gains or loses by the location of the site, the season of the year in which the work is done, the state of the market for men, materials and money and circumstances other than strictly construction work, which affect the cost of the structure; and when contractors are relieved of this gamble, they can bid closer, they can put their energy and knowledge into efforts to turn out good work, and not be constantly on the watch to cheapen the work for their own benefit—maybe salvation—and the owner's harm.

It will be for the owner and bis engineer to say where to cheapen, when to spend, to pay extra prices, if they wish, to speed up work, or secure quick delivery. The job is the owner's; he should handle it and take the profits and the losses.

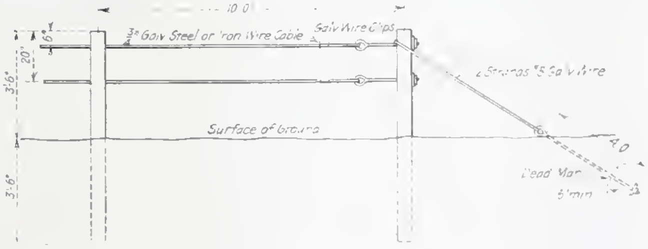
There can be, of course, great dishonesty under "cost plus" contracts, but, if this occurs, it is the owner's fault in lax supervision of his own forces or from incompetent or dishonest engineers.

It is hoped by this paper to obtain an expression of opinion as to the wisdom of substituting "cost plus" contracts for the other forms. At the present time, municipal work is usually required by law to be let to the lowest bidder, and any violation of the custom, even when the law permits, affords a basis for accusations of graft on the part of the officials responsible, no matter how self-evident the lack of ability of the low bidder may be.

If "cost plus" contracts can wisely be substituted for the other forms, the writer conceives it to be a timely occasion to endeavor to have the laws amended so that municipalities as well as individuals can take advantage of it, and also to draft a standard form of contract sufficiently elastic to be adaptable to all usual work, so that the possible disadvantage may be reduced to a minimum and that dishonest officials may be prevented from discrediting a method which, in the hands of honest men, can certainly produce economical, rapid and good construction

Wire Cable Guard Rail

On certain sections of its highways the Pennsylvania State Highway Department is employing wire cable guard rail of the design shown in the accompanying illustration. The cable is made of standard galvanized steel or iron wire and is at least ¾ in. in diameter. The anchors for the end posts consist of a deadman having a minimum diameter of 6 in. and a face area of not less than 4 sq. ft., and a 4 ft. eyebolt. The end post is secured to the anchor by not less than 12 strands of No. 8 galvanized wire. On sections of railing more than 200 ft. in length 1 in. x 2 ft. eyebolts, threaded 18 in., are used. On sections 200 ft. or less in length 1 in. x 12 in. eyebolts, threaded 6 in., are used on one end and bolts 8 in. long, threaded 3 in., are used on the other end. The posts are not less than 6 in. round or 6 in. square, and are heavy brush coated with creosote paint on bottom and on sides up at least 4½ ft. The posts are spaced 10 ft. c. to c. After erection the posts and parts not galvanized are painted with two coats of white lead and linseed oil paint.



Standard Wire Cable Railing of Pennsylvania State Highway Department.

Depreciation Charges on Road Building Equipment. The regulations governing work of the State Highway Department of Arizona provide that upon completion of a project depreciation shall be charged to the project, the equipment being rated on the following basis:

	Per cent per year
Engines, gas and steam	20
Fresnos	100
Graders	20
Mixers, concrete	20
Mules	10
Pile drivers	20
Plows	20
Rock crushers	20
Steam shovels	10
Tents	75
Wagons	20
Wheelbarrows and concrete carts	50

Trucks on daily rate on basis of life of three years. All small equipment such as picks, axes, shovels, etc., on value at time of transfer to new project.

Municipal General Plant Cuts Street Maintenance Costs

Gravel for the upkeep of the graveled and unimproved streets of Indianapolis, Ind., is now being obtained from a municipal plant The city has about 230 miles of these streets and has mapped out a 3-year program for their improvement. This city gravel plant is located on the White River near Kentucky avenue, and has a capacity of 180 cu. yd. of material in 8 hours. The plant is equipped with a ¾ cu. yd. Sauerman cableway excavator, operated by a 50 hp. electric 2-speed Thomas hoist. The plant cost about $5,000 The operating cost is as follows:

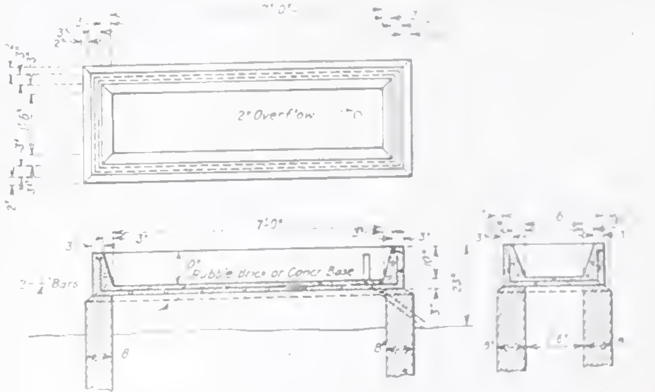
Municipal Gravel Plant of Indianapolis.

Operator	30.00 per week
1 laborer	2.50 per day
Electric power and oil	30.00 per month

The gravel is chuted from the bin into motor trucks having dump bed attachment The city has four of these trucks and the Street Commissioner, A. O. Meloy, estimates that each one does the work of 8 teams He figures the operating cost of a truck at $6.20 per day, of which $3.50 is the wage of the driver, $2.70 is for gasoline at 20 ct for oil The cost for a team is $5.60 per day. The street department also has five tractors which it uses for pulling scraper-graders and 3-way drags in improving its graveled and dirt streets

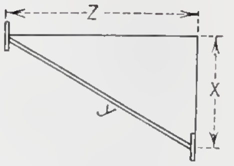
Concrete Watering Trough

The 1919 standards of the Pennsylvania State Highway Department include the concrete watering trough illustrated below. The trough is supported on a rubble, brick or concrete base. If constructed as a separate unit the trough is set upon the base in a mortar bed composed of 1 part cement and 1 part fine aggregate As an alternate it may be constructed directly on the base, the top which is finished with 1:1 mortar before the concrete is placed. A 1:1½:3 concrete is used for the trough, and all exposed surfaces are given a rubbed finish. The inlet and overflow pipes are galvanized steel.



Standard Concrete Water Trough of Pennsylvania State Highway Department.

Table of Actual Lengths of Culvert Pipe for Various Heights of Fill and Skew



The new standards of the Pennsylvania State Highway Department, approved last May, contain the following useful table showing the actual length of culvert pipe for a 26-ft. roadway, and the length for slope culverts for fill ot from 1 ft. to 10 ft. for any skew up to 40 ft. In the diagram X is determined by measurement Z = 28 ft. or 26 ft. + three times average height from shoulder to end of pipe when slope culvert is to be used.

TABLE SHOWING ACTUAL LENGTH OF PIPE FOR 26-FT. ROADWAY, ALSO FOR SLOPE CULVERT FOR FILL OF FROM 1 FT. TO 10 FT. FOR ANY SKEW UP TO 40 FT.

	x	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
For no fill..........	y	28	28	29	29	30	31	31	32	33	35	36	37	38	40	41	43	44	46	47	49
For fill of 1 ft.....	y	31	31	32	32	33	33	34	35	36	37	38	39	41	42	43	45	46	48	49	51
For fill of 2 ft.....	y	34	34	35	35	36	36	37	38	39	40	41	42	43	44	46	47	48	50	51	53
For fill of 3 ft.....	y	37	37	38	38	38	39	40	41	41	42	43	44	46	47	48	49	50	52	53	55
For fill of 4 ft.....	y	40	40	41	41	42	42	43	43	44	45	46	47	48	49	50	52	53	54	55	57
For fill of 5 ft.....	y	43	43	44	44	44	45	46	46	47	48	49	50	51	52	53	54	55	56	58	59
For fill of 6 ft.....	y	46	46	47	47	48	48	48	49	50	51	52	52	53	54	55	56	58	59	60	61
For fill of 7 ft.....	y	49	49	50	50	50	51	51	52	52	53	54	55	56	57	58	59	60	61	62	63
For fill of 8 ft.....	y	52	52	53	53	53	54	54	55	56	56	57	58	59	60	61	62	63	64	65	66
For fill of 9 ft.....	y	55	55	56	56	56	57	57	58	58	59	60	60	61	62	63	64	65	66	67	68
For fill of 10 ft....	y	58	58	59	59	59	60	60	61	61	62	63	63	64	65	66	67	68	69	70	71

When to Remove Solid Tires From Motor Trucks

The Heavy Haulage Co., New York City, according to the Commercial Vehicle, has found it best to remove the tires from the wheels when the rubber is worn down to such a point that the wheel begins to pound, even though there is a certain amount of soft rubber remaining on the wheel. George H. Pride, President of the company, has found, however, that in most instances a tire has outlived its usefulness when the rubber is worn down to a point about 1 in. above the edge of the steel base and that this maximum amount of wear is very clearly indicated by the flattening of the tire in different places on the circumference, which produces the same effects on the truck as is caused on a freight car when it has a flat wheel. Mr. Pride has found that it pays to remove tires while they still have about 1 in. of rubber above the edge of the tire base. Nine years ago, when he got his first experience in motor truck operation, he used to keep the tires on the wheels until the base separation occurred or the soft rubber was worn off. He found that this was a most expensive economy, as the increased vibration produced broken front axles and steering knuckles. The cost of making such repairs was far in excess of the sum saved by running the tires a few hundred miles more.

Tires which wear flat on the surface and which separate from the base have given the Heavy Haulage Co. the most trouble in such few cases as have called for adjustments because the guaranteed mileage was not reached. Flat tires may be caused by imperfections in the tires themselves or by improper care on the part of the truck driver. In the latter instance, a too sudden application of the brakes most often produces flats since the rear wheels become locked and slide along the surface of the pavement without revolving in the ordinary manner. This causes an excessive friction at the point of the tire in contact with the ground, with the result that the tire at that point is worn slightly out of round.

Base separation, when the tire is not defective, may be caused by changing the direction of the truck motion too suddenly while it is traveling at a good rate of speed. Turning the front wheels to a cramped position to get away from the curb while the truck is standing still also produces an excessive side thrust that tends to tear the soft tread rubber away from the hard rubber base.

Other pointers which the fleet owner can follow with good results in order to obtain greater tire mileage include a strict inspection of the truck loading and a close supervision of the drivers to prevent overspeeding. Overloading and overspeeding are two of the most important causes for rapid tire wear. Both should be avoided to the greatest possible extent and when this is done it will be found that the great majority of any of the reputable makes of tires will give at least the guaranteed mileage and in some cases many more miles than set down in the guaranty.

In most cases, it has been found impracticable to fix solid rubber tires by vulcanizing when the tire tread has become brakes. While even the most careless driver knows that cut. Every time a cut in the tire comes in contact with the road, a spreading and tearing action occurs and this soon causes an extension of the cut down to the base and also to the tire. One of the best methods of repairing a cut in a solid tire as to trim out the rubber on both sides of the cut until the cut itself has been entirely removed. Practice has shown that when an attempt is made to vulcanize the two sides of the cut together, that portion of the tire around the cut becomes weakened and under action of heavy loads soon breaks away, weakening the tire almost as much as if the cut were neglected. The safest remedy is to trim out the cut as explained.

Another cause for rapid tire wear is improperly adjusted locking the brakes or skidding produces excessive tire wear, he does not realize that skidding often results from improperly adjusted brakes as well as applying the brakes too quickly. Often skidding results from brakes which are improperly adjusted and when one of the brakes locks or binds at regular intervals in the regular revolution of the wheel, even when the full braking pressure on the pedal is not exerted.

Running trucks in car tracks is another source of rapid tire wear, especially where the edges of the tracks are sharp. While in some cases running a truck on the car tracks results in less damage to the tires than attempting to run it over an adjacent road full of ruts and holes, the wheels should always be turned out of the tracks at switches or frog points, since the sharp switch and frog points tend to cut the tread in much the same manner as a sharp knife.

Industrial Notes

W. I. Alling has been appointed field sales manager of the Oshkosh Manufacturing Co. Mr. Alling's duties will consist, not only in managing the field sales of the Oshkosh Manufacturing Co., but he will also have direct charge of the field service of this firm.

The Driver-Harris Co., Harrison, N. J., is now selling its wire rope products direct to the trade instead of through its former selling agents. These products include sash cord and tiller rope in plain iron, galvanized iron, phosphor bronze, special bronze, monel metal and all special grades. In addition to this, the company has increased its facilities to include all grades of rope in 6x7, 6x12 and 6x19 construction, such as drilling cable, elevator rope, haulage rope, sand lines, etc., in all sizes up to ¾ in.

L. E. Strothman, who for several years has been manager of the steam turbine and pumping engine departments of the Allis-Chalmers Manufacturing Co., left that firm on Aug. 15 to become vice-president and general manager of the Richardson-Phenix Co., lubrication engineers and manufacturers, in which firm he has acquired a financial interest. In making the change J. Wm. Peterson became president and treasurer of the Richardson-Phenix Co.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Street Sweeper—Austin Manufacturing Co., Chicago, Ill., 12 page catalog illustrating and describing new motor sweeper, which sprinkles, sweeps and collects street dirt in one operation.

Crushers—Smith Engineering Works, Milwaukee, Wis., 16 page bulletin devoted to Telsmith Jaw-Crushers; contains data on skid outfits, mounted machines and portable bins. Same company also has issued 16-page bulletin illustrating and describing the Telsmith primary breakers and Telsmith reduction crushers; contains tables of sizes, capacities, weights, etc.

Asphalt Paving Tools—Barber Asphalt Paving Co., Philadelphia, Pa., 8 page bulletin illustrating and describing various classes of tools used in asphalt pavement construction and maintenance.

Trailers—Troy Wagon Works Co., Troy, O., 6 page circular containing illustrations and specifications of Troy Trailers.

Bonus Systems for Users of Trucks and Trailers—Troy Wagon Works Co., Troy, O., 58 page book containing a collection of excellent articles on various profit sharing and bonus systems as applied to trucks, tractors, taxi and bus lines. The titles of some of the articles follow: "Installing a Bonus System," "Possibilities of Truck Efficiency," "Increasing Production by Paying Premiums," "Selecting, Training and Holding Drivers," "A Trailer Bonus Plan," "Methods of Reducing Maintenance Costs," "How a Bonus System Reduces Overhead Expenses," "The A B C of Truck Costs."

Highway Construction—Thew Automatic Shovel Co., Lorain, O. A 20-page, two-color bulletin illustrating and describing the use of the Thew shovel in grading for highways and street improvements.

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials

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The Need of an Organized Defense of the Capitalistic System

The "capitalistic system" needs organized defense if it is to survive. A well organized, aggressive campaign against "capitalism" has been conducted by the Socialists for many years. The growing power of the Socialists in Germany may have been the chief cause of the world war. It is probable that the kaiser hoped to crush socialism by proving to the German people that militarism could be made highly profitable to them. The failure of his attempt enabled the Socialists to secure control of the German government. But it should not be overlooked that the Socialists were able to take control because they were more numerous than any other party. How did they become a majority? By organized, continuous effort to persuade people that socialism is preferable to capitalism. On the other hand, no similar effort was made in behalf of capitalism.

As yet the majority of Americans do not believe in socialism, but at heart most labor unionists are opposed to capitalism and they are growing rapidly in number. An opponent of capitalism usually evolves into an out and out Socialist. So even in America the trend is decidedly toward socialism.

The Socialistic program undoubtedly has certain merits. Were this not so it would not win so many followers. Its chief merit consists in a plan for a more equitable distribution of income. Moreover, Socialists make a strong argument when they point out the costliness of excessive competition under the present capitalistic system. The average man is not a good enough logician to see for himself that a system of production and distribution may be economically sound in its major parts although economically weak in some of its minor parts. To the average mind the proof of any considerable economic weakness in a system is proof of its utter worthlessness. And the average man can be restrained from making this error only by pointing it out to him clearly, repeatedly and convincingly. But what political party or organization is conducting an educational campaign to show the average man that capitalism, in spite of its defects, has superlative economic merits? What organized effort is being made to present to the public facts that show that socialism has greater economic defects than capitalism? Who is spreading broadcast statistic evidence of the failure of Socialism in Australia to give to her citizens a greater general measure of happiness than capitalistic America is giving to hers? Who is gathering and widely disseminating data to show how uneconomic are the government owned telephone and telegraph lines of Great Britain, the government owned railways of France and Italy, and the like?

The fact is that, except for sporadic editorials and articles, the capitalistic system is

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

without defense against the continuous and extensive attacks of the Socialists. Yet the means of defense are not lacking. What is lacking is an organization to defend capitalism, not in its entirety but as to its fundamental principles.

The private ownership of capital involves the payment of interest and the earning of profits. Socialists urge war against both interest and profit. They go back to the ancient theory that interest is usury which no man should exact of another. But all their argument against it is deductive and based on assumed hypotheses. They do not apply the scientific method of comparing results attained where interest and profit exist with results where they do not exist. They do not show that better managers are found in charge of our postoffices, for example, than in charge of drygoods and grocery stores. They do not show that government-owned railways are more progressive and more economic than privately owned railways. In short, they rarely appeal to economic data, but constantly talk a non-quantitative language. Yet no economic problem can ever be solved save by use of quantitative facts. If quantitative facts are not available in sufficient abundance, then by all means let us make measurements, let us make experiments from which measured data can be derived, let us be scientific.

An organized defense of capitalism should not consist solely of arguments, but mainly of data. The defense should also involve an attack, and the attack should be against all attempts to establish the worth of socialism by mere argument without data. If a given method of performing a given kind of work is to be proved more economic than another method, it is futile merely to describe the advantages of the given method in words. Cost data must be produced for both methods before a reliable conclusion can be reached. Precisely the same sort of data must be produced to establish the relative economic merits of socialism and capitalism. To an engineer, since he is a trained and practical economist, this is very plain. Perhaps, therefore, an engineer should organize and direct the campaign of defense of capitalism. Certainly an effective defense is not likely to be made by men that are not themselves experienced economists.

Why Cities Should Issue Bonds for Sewers and Other Public Works Rather Than "Pay as They Go"

Nearly every city engineer is aware of the fact that the sewers of the city are inadequate. State Boards of Health are constantly pointing out many needed improvements, enlargements and extensions of sewerage systems, yet they usually take cognizance only of the most pressing needs of the communities. Why is it that sewerage systems lag behind sanitary requirements? The answer is two-fold: First, because city councils are usually indifferent to the reports of engineers; second, because the raising of funds for construction is either so burdensome upon taxpayers or so inequitable as to lead to vigorous opposition to proposed improvements.

In our issue of Sept. 3 we pointed out that opposition to street improvement comes mainly from owners of leased real estate, for they see only increased taxes without a corresponding increase in rents. The very same sort of opposition to sewerage improvements occurs from the same sources for the same reason.

This sort of opposition can be largely eliminated if the capital needed for sewer construction is raised through bond issues, because the burden of cost is then spread over a term of years. The opposition could be almost completely eliminated were the bonds to mature in not less than 35 years, for then the sinking fund annuity would not exceed 2 per cent, which added to a bond interest rate of 5 per cent, would make a total of only 7 per cent annually to be paid on the cost of the sewer construction.

We are aware that there are many who contend that a "pay as you go" policy is the most economic policy. Some engineers of high standing labor under this delusion. For example, in the February, 1918, issue of "Municipal Engineering," Louis L. Tribus, a well-known consulting engineer of New York City, said:

"As a financial problem solely, the nearer one payment for each property meets the cost of sewer construction, the cheaper in the long run and the more nearly are the best interests of all conserved."

We have frequently pointed out the error in this reasoning. It springs from failure to see that, if a taxpayer pays out the entire cost of his share of an improvement upon its completion, he loses thereafter the interest that he could have secured on the money thus paid out in taxes. Since the average taxpayer can so invest his capital as to earn 6 per cent or more, he is better off financially if he lets the city raise the capital for construction at 4.5 to 5 per cent. He then pays only 4.5 to 5 per cent, in the form of taxes whereas he is receiving 6 per cent or more. Engineers who have themselves not engaged in business are prone to overlook this important economic fact, and the same holds true of other professional men and of salary and wage earners generally. Hence the prevalence of the sophistry that it is cheaper in the long run to "pay as you go" for public works.

Under antiquated charters that limit their bonded indebtedness to 2 or 2.5 per cent of the assessed value of all property, many cities are up to the debt limit, or so near to it, that they can not issue any more bonds for extensive improvements, regardless of urgent need. Engineering societies should undertake to secure revision of laws and charters that thus hamper municipal development. Of course it will be desirable to place some limit on the allowable, bonded indebtedness of every city, but the limit should have a rational basis, which it now lacks. Moreover, a limit should be assigned to each class of improvement. Waterworks bond issues might well be limited to $30 per capita, which would be about 75 per cent of the total cost, at prewar prices, of an adequate water works system for the average city. Sewerage system bond issues might be similarly limited. There are various ways whereby bond issues can be rationally restricted.

The beneficiaries of an adequate sewerage system are as numerous as the inhabitants of the city. Hence tax assessments for sewers should be met directly or indirectly by everyone having an income. If long-term bonds are issued for sewer improvements, then landlords will be able to reimburse themselves from rents, although in such a case the needed increment in rent would be so slight as to be ignored by nearly every landlord.

Civil engineers have been accustomed to design public works and to report upon their probable cost and economic worth. They have seldom gone further than this. But the time has come for civil engineers to act as promoters of worthy projects and improvements. In their capacity as promotors they must secure rational laws and charters covering the financing of public works. Here it is that engineering societies can be of great benefit to the public. Let individual engineers continue to do the designing. Let engineering societies engage in promoting public works.

The Relative Value of General Principles and of Details

The opinion is prevalent among teachers, especially in the scientific field, that students should be taught "general principles," but that "details" and data should be acquired, for the most part, after graduation. The result of this educational practice is to imbue the average student with an inordinate respect for "general principles" and the theories that explain them, and to lead the student to feel a mild sort of contempt for details of practice. Most educators will disclaim any intention of belittling the value of knowledge of details, but the fact remains that their one-sided teaching habituates students to trust altogether too much to their knowledge of principles.

Not many years ago a hydraulic engineer told the editor that he had ceased studying engineering periodicals, because he knew all the general principles of hydraulics and had acquired sufficient knowledge of details of practice to enable him to design any works or structures that fell within his engineering province. He was the engineer who designed and built a filter to remove algae from a city water supply, when the "trick could have been turned" at a nominal expense by applying knowledge of a detail that he did not possess, namely the knowledge that copper sulphate will kill the algae.

Another hydraulic engineer some years ago recommended the expenditure of more than half a million dollars for a long pipe line and reservoir, in order to secure a water supply free from algae and danger of typhoid contamination. An expenditure of about $25,000 would have effected the same purpose, had that engineer possessed sufficient knowledge of two or three details. He knew that chlorine treatment of water reduced the number of typhoid cases, and he knew that in some cities the chlorine treatment had been highly efficient; but he did not know why there was a lower efficiency in some other cities. So his lack of detail knowledge of the causes of the variation doubtless led him to hesitate to recommend chlorination. For this he was not at that time to blame, but we mention the matter to show that had he then possessed the detail knowledge about chlorination that is available today, he would have known that the water in question could be chlorinated so as to secure complete freedom from typhoid germs.

Still he might have hesitated because he feared that the algae could not be removed without expensive filtration. In that case, however, he knew that copper sulphate is effective on small bodies of water; but he doubtless feared that it could not be effectively applied to the rather large lake from which the city was securing its supply. Here again a knowledge of one detail might have saved the day. The algae in question grow along the edges of the lake, and cast their spores upon the surface of the water. The winds sweep the spores about, and unless they are carried away by an overflow from the lake they develop into weeds that die and pollute the water. Knowing this detail the solution of the problem is simple. Treat the margins of the lake with copper sulphate in the late spring and early summer. Build a small dam to hold back the flood waters, and secure an ample overflow from the lake throughout the summer, and thus draw off the algae spores before they develop into fresh water seaweed.

We could give many other illustrations of the great worth of a knowledge of one or two details, which would not be classed as general principles. Because of the value of such knowledge students should be habituated to acquire it and to respect it. After graduation they would then continue systematically to add to their knowledge of details, even though they were well acquainted with all the general principles of their specialty. As it is, many practicing engineers are "too busy to read." It were better for their employers were they to schedule their working time so as to devote a considerable part of it every week to reading and memorizing details relating to their professional work.

Book Reviews

The Construction of Graphical Charts. By John B. Peddle, Professor of Machine Design, Rose Polytechnic Institute, Second Edition, Revised and Enlarged. Cloth, 6x9 in., 158 pp., ill. McGraw-Hill Book Co., New York.

The value of charts which can be used by the engineer or designer for the solution of formulas and equations is greatly increased when the user has sufficient knowledge of the underlying principles of their construction. It is the purpose of the author in this work to familiarize the engineer with various methods of chart construction and to bring out these principles.

A knowledge of advanced mathematics is necessary to understand the different processes.

The book begins with simple charts involving the use of rectangular co-ordinates. Alinement charts with numerous examples receive a liberal share of attention, and hexagonal chart construction methods are freely developed. Of the latter the advantages as well as the disadvantages are pointed out.

Several examples of proportional alinement charts serve to emphasize their structural simplicity. Charts for earth pressure, centrifugal force, piston rod diameters and others illustrate this type of chart and its method of construction.

One chapter is devoted to the subject of empirical equations. The difficulties involved in the selection of an equation to fit a given curve, except in simple cases, are well illustrated.

The principal addition to this second edition is a chapter on the use of determinants. The construction of alinement charts, in particular, may be greatly simplified by their use.

Construction Features of Grand River Roller Crest Dam

The Grand River dam, the diverting structure for the high line or main canal of the Grand Valley Project of the U. S. Reclamation Service, may be briefly described as a steel roller crest surmounting an ogee concrete weir, with a sluiceway and a canal intake of a capacity of 1,425 cu. ft. per second at its west end. The most notable feature of the dam is the roller crest by which the entire upper 10 ft. of the dam can be lifted above high water, so that the elevation of backwater surface in flood is no greater than during operation for maximum requirements in low water.

The problem which was met by this construction was that of raising the headwater a sufficient height to furnish the required flow in the canal during the low season, and at the same time provide means for passing floods without raising the water surface to a point that would endanger the near-by railroad grade. Since during some seasons it appeared that it would be necessary to conserve every drop of water possible, the simple wicket dam was out of the question because of the excessive leakage inherent in that design. The alternatives, then, were some form of Taintor or Stoney gates and the roller crest. The cost of the several designs was found to be not very far apart and the roller crest was chosen because of the expediency of providing the much wider waterways permitted by that design and because of its simplicity and ease of operation. The construction features of this roller crest dam are described by O. T. Reedy, Engineer U. S. Reclamation Service, in the August Reclamation Record, to which we are indebted for the matter that follows.

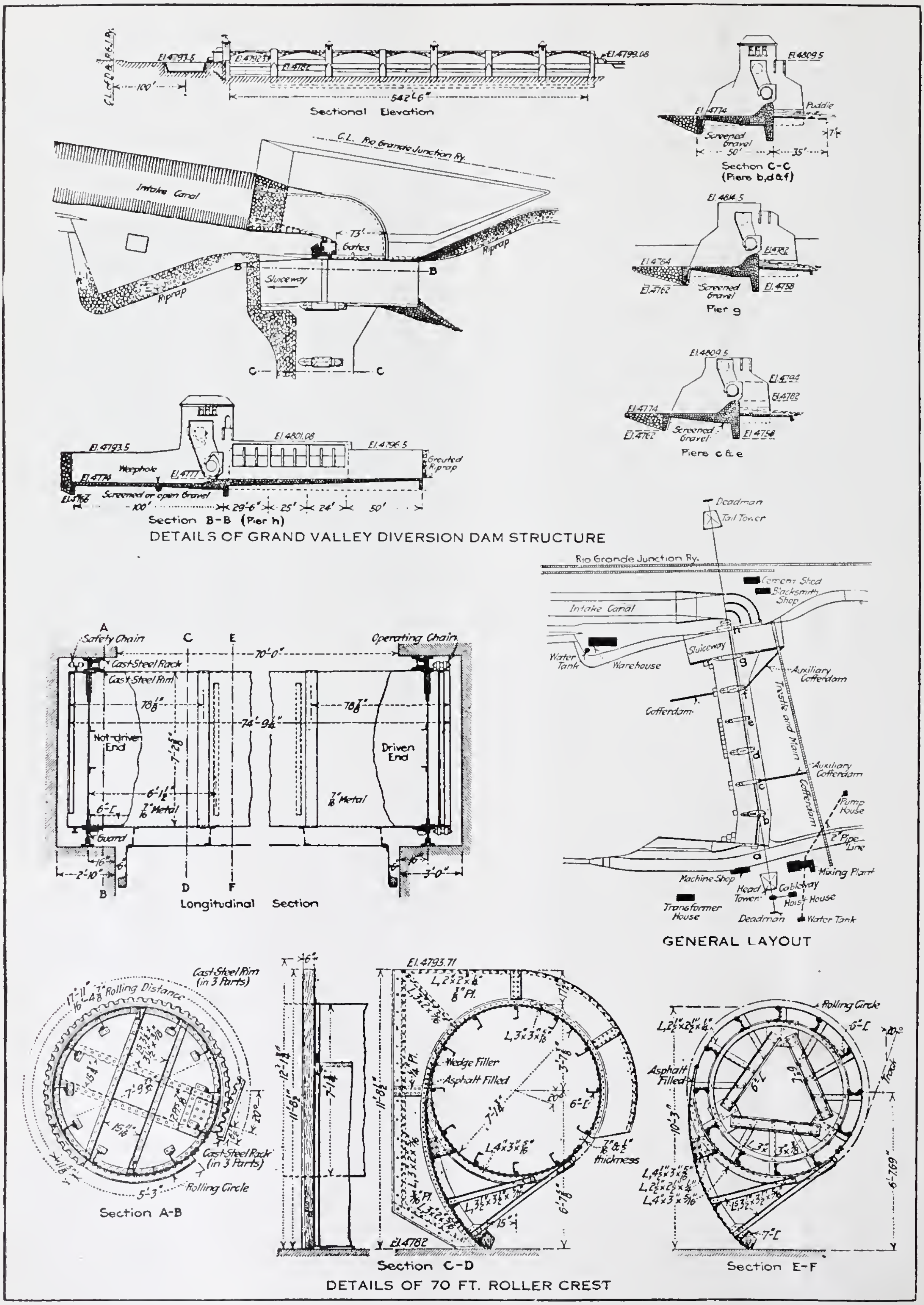
The axis of the dam is normal to the direction of the river. On the west is the canal intake controlled by 9 regulator gates, each 7 ft. square. These gates are operated by a line shaft installed on the head-wall platform. The quantity of water required for the canal can be drawn through 8 of these gates thus permitting any one to be out of commission without decreasing the intake capacity to a point below requirements. The velocity through the gates is a little less than 4 feet per second for maximum canal draft.

In front of the intake head wall is the sluiceway 60 ft. wide and 235 ft. long. The sill of the sluiceway rolling gate is 8 ft. 4 in. lower than the sill of the intake gates and the entrance to the sluiceway is 6 ft. 4 in. lower, thus permitting water to be drawn into the canal from the upper stratum and causing the silt to be deposited in the sluiceway. It is assumed that a velocity of about $2\frac{1}{4}$ ft. per second at the entrance of the sluiceway is required to carry silt on into the canal, and the sluiceway will take a deposit almost $2\frac{1}{2}$ ft. deep at its entrance before this velocity is reached. When the deposit of silt reaches this depth the sluiceway roller is raised and the sluiceway channel cleared by flushing the mud down the river.

The dam proper consists of 6 bays, each 70 ft. wide, or a total of 420 ft. With an assumed flood-water level of 1,592.7, which is the same elevation as that of the top of the rolling crest when in place, it was computed that a discharge of 50,000 second-feet could be taken by the 6 bays and the 60 ft. sluiceway and in addition about 1,600 cu. ft. could be carried by the canal intake. This discharge, 50,000 second-feet, was the highest flow recorded on the river during the period of 18 years previous to the construction of the dam, and occurred but once during that period, and then for a very short time only. This flood was duplicated, however, the summer following the beginning of construction and again in the summer following the completion of the dam. The 6 bays alone carried the latter flood, with an elevation about that of the top of the closed sluiceway roller, the water occasionally just lapping over the crest.

The dam rests on gravel. There is some sand and also some cobblestones, but the principal material is gravel. Borings made in the stream a short distance above the dam site and also a short distance below indicated that rock foundation would not be reached at less than 30 ft. depth, and hence the dam was designed on the basis of exclusively gravel foundation. As a matter of fact on a portion of the dam rock was encountered before reaching the designed bottom elevation of the main cut-off.

At the time this design was made, there were but two rolling crest dams in this country, one being a short single roller controlling a logway in the Boise Dam of the Re-



DETAILS OF GRAND VALLEY DIVERSION DAM STRUCTURE

GENERAL LAYOUT

DETAILS OF 70 FT. ROLLER CREST

Details of Grand Valley Diversion Dam Structure and of 70 ft. Roller Crest.

clamation Service and the other being an installation of three rollers in the Washington Water Power Co.'s dam at Long Lake near Spokane. There were, however, some 20 or 30 dams of this character being successfully operated in Europe and perhaps half that number in other parts of the world. The Grand River Dam is now the largest of any in the world from the standpoint of combined height and length, although there have been constructed single spans of both greater height and greater length.

Authority to begin clearing the site and construct camp was received in August, 1913. The first concrete was placed on Jan 9, 1914, and piers were ready to receive the roller crests as soon as the fabricated material began to arrive, early in 1915.

It may be well at this point to take up briefly the description and history of the roller crests. The main rollers consist each of a hollow steel cylinder 74 ft. 9¼ in. long and 7 ft. 1¾ in. in diameter, the ends projecting about 2½ ft. into recesses in the piers, and rolling on smooth tracks embedded in the side of the recesses at an angle of 20° with the vertical. Around each end of the roller is a toothed rim engaging a toothed rack fixed parallel with the track. Operation is effected by means of a chain, one end of which is fastened to and partly encircles the roller, the other being wound around a drum in the hoist house on top of the pier.

The hollow cylinder acts as an axle, and the required height of the crest is obtained by fastening to the cylinder an extension shield which rests on the sill when the roller is down, thus forming the bottom seal. The ends are sealed by means of oak strips attached to flexible diaphragms near the ends of the cylinders. The sluiceway roller crest is built on essentially the same design but with different dimensions.

The patentees submitted three different schemes for the roller system, all of which included the 15 by 60 ft. sluiceway roller. The other rollers were all 10 ft. 3 in. high and the schemes contemplated seven rollers of 60 ft. length, six rollers of 70 ft. or five rollers of 84 ft. It was found that there was practically no difference in the cost of the three schemes and the one of six rollers each 70 ft. long was chosen, as that was the layout on which had been based most of the plans. The patentees were so advised and asked for proposals, first, for the fabrication of the rollers and, second, for royalty required if rollers were fabricated in this country. Upon receipt of these proposals the Washington office advised that—" * * * from all information available it is believed that little, if any, saving in cost to the United States would result from securing fabrication of the dams by American manufacturers, whereas there would certainly be a very material loss of time in preparing drawings and specifications and in advertising for and acting upon proposals with the possibility of very serious further delay on account of the necessary exchange of communications between the German company and the manufacturers in this country."

Authority to enter into contract with the German company was therefore requested and received from the secretary and it was notified by cable of the acceptance of its offer. This was early in 1914. In August of that year it became evident that the company would not be able to complete its contract, by reason of another little contract the German government had undertaken, which, it seems, it too, was unable to complete. A little later the director received a letter from the company advising that it could not continue with the contract and the matter of working over the general drawings to conform to American practice in fabrication was immediately taken up. The drawings were completed and submitted to bidders in October. Seventeen bids were received, running from $15,000 to $50,000. The contract was awarded to the Riter-Conley Co., of Pittsburgh, delivery to be made in seven shipments, beginning Feb. 8, 1915, and running to March 22, 1915. There was from three to five days' delay in the first six shipments and 17 days in the last. This contract covered the rollers only. Contracts for the hoists were awarded to the Link-Belt Co and the Minneapolis Steel & Machinery Co. for the 60-ft. and 70-ft. rollers, respectively.

The greater portion of the piers had been completed before the racks were received, and the concrete had been spared in box-like forms for the purpose of later receiving the rack supports and anchor bolts. The racks were placed in the following manner. By means of the transit and steel tape, two marks were set (on small tin plates attached to the concrete) in each plane of the face edge of the racks, normal to the axis of the roller and 72 ft. 6 in. apart, which distance is that between the face edges of the toothed rims on the roller. One of these marks was a few inches above the top of the rack and the other a few inches below the bottom. A fine steel piano wire was then stretched in each of the planes mentioned, and its position adjusted with reference to the tin plate marks (whose coordinates had been accurately determined by measurement and computation), so that it was [illegible] in., measured normal, from the required position of the face edge. The racks were attached by adjusting bolts to iron bars, held in position on a timber frame. The nuts on the bolts were then turned until the face edge of the rack was in proper relation to the piano wire. To check whether the rolling surfaces of the racks for any roller were in the same plane, a horizinotal wire was stretched across the span between the two face edges, and the rack adjusted so that the whole rolling surface was just touching the wire. When the position of the rack was satisfactory, a thin grout proportioned 1 to 2 was poured around the steel support and the anchor bolts and allowed to harden.

There had been so many complications and delays in receiving the steel rack supports, anchor bolts, and other auxiliaries that erection was thrown considerably later in the season than was expected, and it was necessary to partially assemble the rollers, raise them to a position out of danger and then to let the water through the bays and under the rollers and continue the assembling from staging.

The rollers were each shipped in five sections, the two ends each about 13 ft. long, upon which the toothed rims are attached; the two adjoining pieces each 21 ft. long and a closing section 6½ ft. long. The two ends were swung into approximate position on the false work by the cableway and with bars and jacks the proper teeth of the racks and rims were brought into mesh. The two adjacent pieces were then joined to the ends and held to place with barrel pins and fitting-up bolts. The pieces were then adjusted for line at all parts of the circumference, and the opening between made about ¼ in. longer than the slip or closing section, in order to make for ease in getting it into place. When this was done, the ends were drawn together with pulling jacks, and the splice plates put on and held by barrel pins and fitting up bolts. The roller was then tested with the wye level, and the riveting done.

As soon as the stream could be turned under the river rollers, the sluiceway was cofferdammed and unwatered, and erection begun on the sluiceway roller. This was completed during the highest water of the season.

Service across the dam and between the hoist houses is made convenient by a light steel bridge spanning the bays at the upstream ends of the piers.

The dam was put into commission late in June, 1915.

The engineers charged with the design of the dam were R. F. Walter, then supervising engineer of the central district now assistant chief of construction, J. H. Miner project engineer; Frank Teichman, designing engineer from the Washington office; and O. T. Reedy, construction engineer. D. C. Henny was the chief consulting engineer for the board. J. C. Whitney was superintendent of construction.

New Laboratories of U. S. Bureau of Mines. The new $1,000,000 laboratories of the U. S. Bureau of Mines will be dedicated on Sept. 29. The fuel investigations of the Bureau of Mines constitute a large and important part of the work of the bureau and ample recognition of this fact will be seen in the arrangements of the new laboratories and their equipment for the highest grade of research and routine work. It is here that typical coals, gathered from all parts of the country, are analyzed and tabulated in such a manner as to give to the public general information of the coal fields of the country. It is also here that the actual experiments in the combustion of coal take place under experts and their findings given publication.

Annual Meeting of Public Health Association. The annual meeting of the American Public Health Association will be held Oct. 27-30 at New Orleans, La. The program for the sanitary engineering section of the association includes committee reports on sanitary control of waterways, on water works operation and analytical methods, on sewage work-operation, on refuse collection and disposal and on milk pasteurization. In addition several papers will be presented.

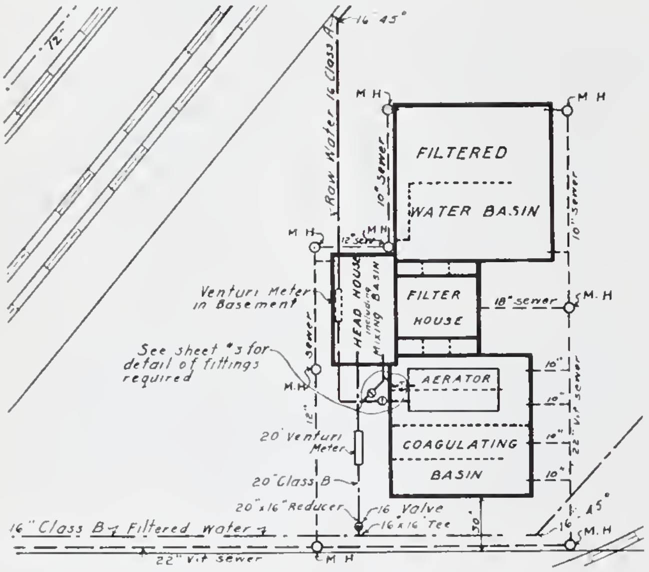
New Water Filtration Plant of Whiting, Ind.

By RENVILLE S. RANKIN,

Engineer with Pearse & Greeley, Consulting Hydraulic and Sanitary Engineers, Chicago.

Whiting, the Standard Oil city of Northern Indiana, is one more community which will soon be added to the ever-increasing list of cities along lower Lake Michigan that are supplied with filtered water. Whiting is at present constructing a 4,000,000-gal. water filtration plant.

Increasing pollution along the shores at the lower end of the lake renders the water unsafe in spite of precautionary measures.



Layout of Water Filtration Plant of Whiting, Ind.

Extension of present short intakes would furnish doubtful relief, and the only safe remedy seems to be a well-operated filter plant.

Whiting, a city of 8,200 inhabitants, is in the heart of a great industrial district. Within a radius of a few miles lie Indiana Harbor, East Chicago, Hammond, South Chicago and Gary. At present, all of the wastes from this manufacturing region eventually reach Lake Michigan. The Standard Oil Co. refinery, however, owing to its proximity to the city, produces the wastes that are the most difficult to treat. At times these wastes impart a very disagreeable taste and odor, and render the water very unpalatable. In addition, the intake to the pumping station does not extend far enough into the lake to prevent excessive turbidity even during very moderate storms.

The supply is drawn through a brick tunnel to pumps located in the main pumping station of the Standard Oil Co. From there it is pumped into the city mains. At present a liquid chlorine apparatus is used to safeguard the city.

The consumption in 1916 at the time of special tests was 3,400,000 gal. per 24 hours or 425 gal. per capita. There are no meters and it is needless to say that a great waste exists, due probably to leniency on the part of the Standard Oil Co. which furnishes the supply. Certain restrictive measures will be adopted so as to postpone additions to the filter plant.

The Testing Station.—Previous to the design of a filter plant for a community, through information about the character of the water that is to be purified must be secured. As a rule, no two waters are capable of the most efficient purification by identical methods. The municipal supply at Whiting is no exception. On account of the predominance of the oil wastes, and the lack of sufficient data upon which to base the design of a plant to treat such a water, it was thought best to construct a small testing station.

The station was operated for the purpose of obtaining the solution of certain problems: (1) The effect of aeration on the odor and taste. (2) The kind and amount of chemicals to be used. (3) Sedimentation periods, rates of application and washing which would produce maximum results.

The testing station was operated for about three months in all. The results well justified the expense. Aeration improved the quality of the water, but the improvement was not entirely uniform. When the wind was off shore and heavily laden with impurities the spray washed them out and deposited them as a black oily scum upon the settling basins. Nevertheless, the use of aeration was helpful at all times as the water required less chemical to accomplish the final removal in the test filter. This was due probably to the breaking down of an emulsion. Alum was the only chemical used and it proved successful. The dosage required was less than one grain per gallon. Frequent washing to maintain the normal rate of filtration was a troublesome problem. It was finally solved by shaking the filter, i. e., by opening the wash water valve for a moment and closing it. In this way the period of service in the test filter was lengthened from 3 or 4 hours to 16 and the consumption of wash water was correspondingly reduced.

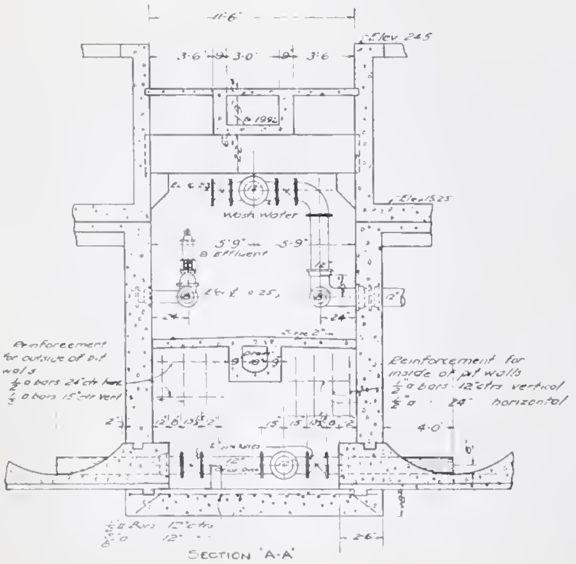
Considerable data, expensive to acquire in a completed plant, were thus obtained from the operation of the testing station in advance of actual design.

The Filtration Plant.—The design for the filtration plant at Whiting combines all of the requirements which the operation of the testing station showed were essential.

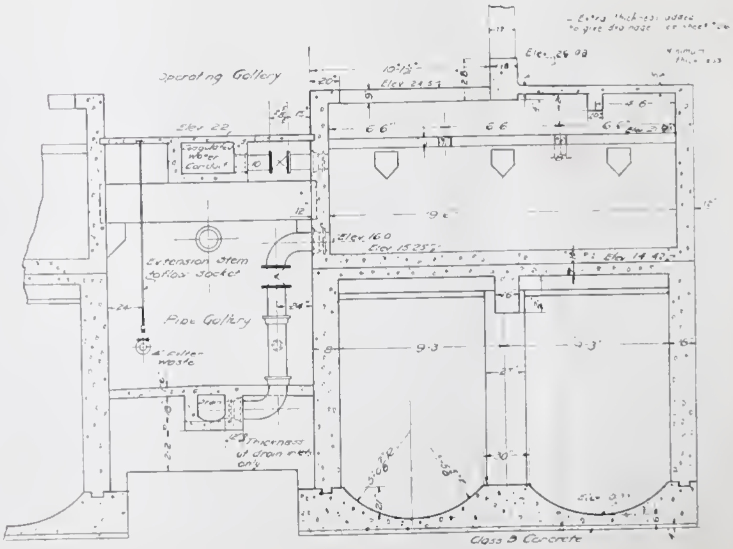
The principal elements are, an aerator, a mixing basin, two coagulating basins, six filters, a filtered water basin, and the head house.

The capacity of the plant, based upon the filters, is 4,000,000 gal. per 24 hours. Provisions for enlargement are also made.

Water is supplied from the pumping station at the Standard Oil Co. about ½ mile distant, to the aerator, from which it flows by gravity through the plant to the filtered water storage basin. From there it is pumped by high service pumps into the mains.



Cross Section Showing Waste Water Piping.

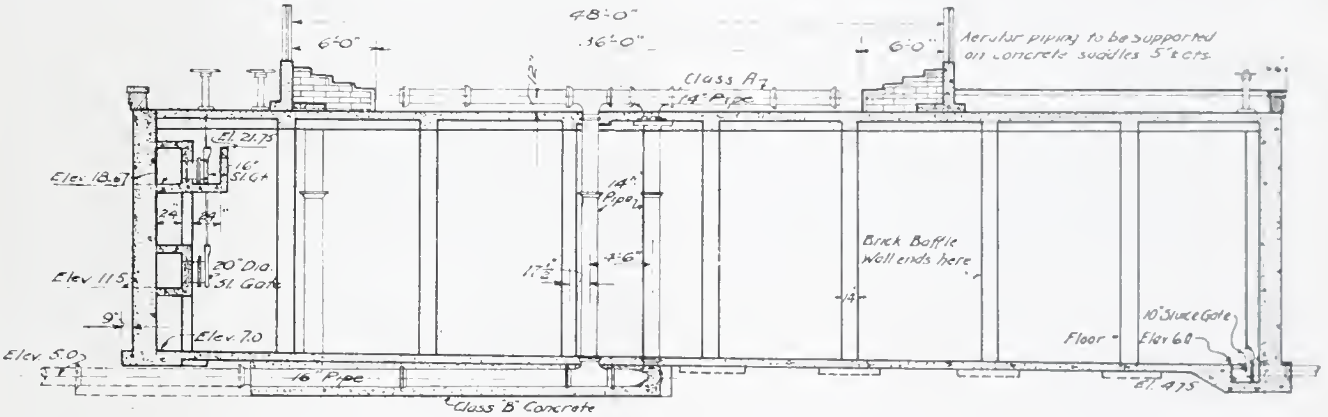


Cross Section Showing Location of Drain Lines.

The aerator is located on top of the coagulating basin roof. Structurally, it is a basin 30 ft. by 48 ft. in plan, surrounded by a concrete wall 3 ft. 6 in. high with vertically grooved columns on top for inserting stop planks between to confine the spray. The bottom of the aerating basin is stepped to a central collecting basin. Two 14-in. cast iron pipes, 8 ft. apart, lie on the floor of this basin and are tapped on 3-ft. centers for 22 No. 13A Spraco nozzles. The spray is directed, not vertically, but slightly inclined so that the two rows of sprays will collide. The spray in falling cascades down a few steps to the pool in the center which is kept at a fixed depth to retard freezing.

The water from the aerator enters the mixing basin which is in and practically on a level with the second floor of the head house. It was placed there for two reasons in particular, first, for purpose of observation and second, to reduce the length of chemical pipe lines.

The mixing basin is approximately 33 ft. by 12 ft. with an average depth of 5 ft. it has 4-in. brick baffle walls of around-the-end type spaced on about 2-ft. centers. The outlet from the mixing basin leads directly into a mixed water conduit which passes through the head house wall into the coagulating basins.



Section Through Aerator and Coagulation Basin.

There are two coagulating basins, separated by a dividing wall, each 40 ft. by 81 ft. with an average depth of 16 ft. The capacity of the two basins is about 700,000 gal., providing a sedimentation period of 4.2 hours on a 4,000,000 gal. rate or 3 hours on a 6,000,000 gal. rate. The basins are covered with a concrete roof of the beam and slab type of construction. The roof is supported by 14-in. square columns spaced 10 ft. 4 in. both ways. Drainage of the basins is obtained by a 1 ft. slope in the floor with 4 10-in. sluice gate outlets in sumps located at the low points. The inlet to each basin from the mixed water conduit is a 20-in. circular sluice gate, and 2 30x36-in. sluice gates in the dividing wall provide a cross connection for operating the basins in series. An 8-in. brick baffle wall extends from one end down the center of each basin to within 10 ft. of the opposite end. The outlets to both basins are similar and consist of an overflow or skimming weir discharging through 2 16in. circular sluice gates to a settled water conduit lying directly over the influene or mixed water conduit. Both of these couduits are 24x28 in. in section and are supported along one wall of the basin. The settled water conduit re-enters the head house, passes through it to a right angle turn and down the center line of the filter pipe gallery.

Six filters, 12 ft. by 19 ft. 6 in. each, have a filtering area of 234 sq. ft. each and a rated capacity of 666,000 gal. or a total of 4,000,000 gal. per day. Each filter has 3 concrete wash water gutters which run across the width of the filter and discharge into an 18-in. main gutter which runs lengthwise. A 12-in. connection leads to the main drain in the pipe gallery. The influent to each filter is a 10-in. pipe.

The filtering medium consists of 30 in. of sand and 15 in. of gravel with underdrains of the Harrisburg type. The effluent passes out through an 8-in. rate controller and returns to the auxiliary filtered water storage basin underneath. The 12-in. wash water supply line is suspended directly beneath the concrete influent conduit in the pipe gallery with 12-in. laterals to each filter. The rate of wash is estimated at 15 gal. per square foot per minute. A 4-in connection for filtered water waste is also provided. All of the valves are hydraulically operated from an operating table with the exception of the 4-in. waste valve which has an extension stem leading to a nut in the operating floor above.

The pipe gallery is 11 ft. 6 in. wide and the arrangement of the pipes is such that a clear space about 5 ft. wide and 7 ft. high down the center is provided. The main drain is of concrete and runs directly beneath the pipe gallery floor. The filters are divided in 2 sets, 3 on each side of the pipe gallery. Each set is supported upon an auxiliary filtered water basin 45x18 ft. by 11 ft. The outlet to both of these basins is into the filtered water storage basin.

The filtered water storage basin is approximately 94x91 ft. and 14 ft. deep. With the two auxiliary basins beneath the filters, a total storage of approximately 890,000 gal. is provided. This is equivalent to 5.3 hours' storage at a 4,000,000 gal. rate. The floor of this basin is below ground water level and provision for uplift was necessary. The design adopted is an inverted flat slab with panels 10 ft. 8 in. by 11 ft. 6 in. The supports are 14 in. columns which in turn support the roof. The roof is a beam and slab type with the slab supported on four sides. A 2-ft. earth covering has been provided. The basin is baffled with 8-in. walls to prevent dead water areas. The outlet to this basin is into a conduit, low enough to drain the basin, which leads into the basement of the head house. Into this conduit the high lift and wash water pump suctions are connected.

The head house is a 4-story structure, including the basement. The basement contains heating plant, coal storage, elevator machinery, but principally the pipe connections to the pumps located on the first floor above.

For high service duty two 3,000,000-gal. and two 5,000,000-gal. pumps are provided, so connected that each set may pump separately or in combination forming a two-stage pump. The wash water pump is a 5,000,000-gal. pump, designed for direct washing of the filter.

The second floor contains the offices, laboratory, chlorine room, shower bath and locker room on one side of a passageway and, on the opposite side, the mixing basin and the lower portion of the chemical solution tanks with the orifice boxes. Space for a dry feed chemical machine is provided. Alum will be stored on the third or top floor.

The second floor passageway opens directly onto the operating floor of the filters, and the first or pump room floor connects down a few steps into the pipe gallery. A doorway at the opposite end of the pipe gallery is provided.

The plant is located along the main line of the Pennsylvania R. R. and on one of the principal thoroughfares of Whiting. It was decided, therefore, to make the plant artistic from an architectural standpoint as well as useful for utilitarian purposes.

The superstructure is of brick with a concrete shell. Stone window sills and copings, and a stone entranceway add to the attractiveness. The roof is flat with pyrobar roofing supported on concrete beams. The exterior walls of the basins are exposed on practically all sides and to relieve the monotony they are to be paneled in the concrete and surmounted with a coping.

Costs.—Bids for the entire work were opened on June 2, 1919. The work was divided in two contracts. Contract No. 1 was for everything except furnishing the 5 pumps. The bids were quite uniform and the main contract was awarded to Chas. W. Secord of West Pullman, Ill., for $179,742. Contract for the pumps was awarded to the Cameron Pump Co., for $11,845.

The preliminary work, operation of the testing station, and the preparation of plans and specifications for the complete plant, were made by the firm of Pearse & Greeley, Hydraulic and Sanitary Engineers. John R. Longley, from the same office, is resident engineer on the construction work. With favorable conditions, it is expected that the plant will be completed next spring.

Flat Rates vs. Meter Rates

With an increase of 65 per cent in the total number of consumers during a five-year period, and a decrease of 27 per cent in the quantity pumped during the same period as a result of changing from flat rate to a meter rate, the water works system of Tuscaloosa, Ala., finds that the flat rate system is unjust to the consumer. C. E. Abbott, Superintendent of Water Works, in a paper read before the annual convention of the American Water Works Association at Buffalo, June, 1919, gives in detail the comparison of the system on flat and meter rates. The following abstract is taken from Mr. Abbott's paper:

In 1911 the plant was operating upon a flat-rate basis. We commenced installing meters in the fall of 1913, with the idea of metering the entire system, which was practically completed in 1915. Beginning with the year 1916 the plant was operating upon practically an all-meter basis.

The figures covering the operations during the year 1911 are as follows:

Number of consumers at end of 1911:	
Flat rate	927
Meter	42
Amount of water pumped during entire year	317,335,980
Average amount of water pumped daily	869,413
Number of tons of coal used during year	3,285
Cost of coal, $2 per ton.	

The figures covering the operations during the year 1916 are as follows:

Number of consumers at end of 1916:	
Flat rate	190
Meter	1,414
Amount of water pumped during entire year	230,779,985
Average amount of water pumped daily	632,274
Number of tons of coal used during year	1,215
Cost of coal, $1.95 per ton.	

Comparisons of the Statistics for the Two Years 1911 and 1916.

Total number of consumers in 1911	969
Total number of consumers in 1916	1,604
Numerical increase in numbers of consumers	635
Representing an increase of 65%.	
Amount of water pumped during 1911	317,335,980
Amount of water pumped during 1916	230,779,985
Numerical decrease in gallons pumped	86,555,995
Representing a decrease of 27%.	
Number of tons of coal used during 1911	3,285
Number of tons of coal used during 1916	1,215
Numerical decrease in number of tons	2,070
Representing a decrease of 63%.	

All the above figures are taken from the records of the City Commission of Tuscaloosa, Ala., and can be verified upon inquiry.

It will be noted that while employing the meter system almost entirely, we still have 190 consumers receiving water on a flat rate. This condition arises from the fact that these 190 consumers live outside the sewer zone and have each only one opening on the premises, and 20 meters placed on consumers under identically the same conditions show that 50 per cent of the minimum allowed under the flat rate is never reached.

With the meter system in operation during the year 1916 we were enabled to account for 85.8 per cent of all the water pumped during the year. The figures in substantiation of this are as follows:

Total meter reading for domestic consumers	114,186,777
Total meter reading for manufacturers, etc	58,144,125
Total meter reading for filter wash water	9,552,660
Total meter reading for schools	2,920,460
Estimated amount used in street sprinkling, etc	11,182,000
Total amount of water accounted for by records	196,986,022
Total amount of water pumped during year	230,779,985
Water unaccounted for	33,793,963
Representing a percentage of only 14.2 of the total amount pumped unaccounted for.	

The Silting Up of Reservoirs

In all reservoirs built in the western part of America, and especially in those built in a stream bed by damming the channel, the silt problem is one that must be faced sooner or later; and unless some means can be found for removing the silt deposits, the accumulation will impair, materially, the storage capacity of the reservoir, and, at some date, controlled by local conditions, the entire basin will be filled to the brim. This is particularly true of the ephemeral, flashy streams, dry a considerable portion of the time and subject to freshets and floods at intervals. At such times the floods of water coming down the dry beds will erode the bottoms and banks to a great extent, much more so than if the stream bed was continually wet, and the accumulation in the reservoir will be much greater when the reservoir is in the stream channel, as the entire débris of the erosion, whether carried in suspension by the water or rolled along the bottom, will be deposited in the reservoir.

An interesting discussion of this problem with special reference to the silting up of the Zuni Reservoir in New Mexico, is given by Mr. N. F. Robinson in the August Proceedings of the American Society of Civil Engineers, Vol. xlv, No. 6, pp. 483-493. An abstract of his paper follows:

The Zuni Reservoir is in the Zuni Indian Reservation in Western New Mexico, about 45 miles south of Gallup. It is formed by the construction of a dam across the Zuni River, a tributary of the Little Colorado.

The dam is a combination rock and hydraulic fill. The rock fill has a height of 80 ft., or from the bottom of the puddle trench to the top of the parapet 110 ft., the length over all being 780 ft. There are 40,000 cu. yd. of rock in the fill, and 60,000 cu. yd. of the hydraulic fill. At the point where the dam is built, the stream has cut through a lava flow, and the two abutments are composed of the lava or basalt. As originally constructed, the spillway of the Zuni Reservoir was at Elevation 1,000, but when the new spillway was built, it was placed 9 ft. lower.

The reservoir was built between 1902 and 1907, the gap in the stream being closed in 1906, from which time water was impounded; but, until August, 1909, only a small portion of the reservoir capacity had been stored.

The quantity of silt brought into this reservoir is very great, and in the 12½ years since the channel was closed, has amounted to about 4.86 per cent per annum of the reservoir capacity to the elevation of the present spillway. For the total period of 12½ years, the run-off has been 326,648 acre-ft., the silt deposit 5,507 acre-ft., and the average silt content, or deposit of the water, 1.88 per cent.

In addition to this silt deposit, which only represented the quantity left in the reservoir, a considerable quantity has been carried out of the reservoir through the gate-valves, and, during the last period, it is probable that a large quantity carried in suspension passed over the waste-way. Considerable water has been wasted through the valves back into the river, it having been necessary to do this, especially of later years, in

TABLE 1—SILT DEPOSIT IN THE ZUNI RESERVOIR FROM ORIGINAL CLOSING OF CHANNEL IN 1906, TO JANUARY 1, 1919.

All capacities and silt deposits in acre-feet.

	Original, 1906.	June, 1910	Jan., 1912	Jan., 1914	Jan., 1918	Jan., 1919	Total period
Total silt deposit	0	1,801	3,144	4,200	5,507	6,186	6,186
Length of period, in years		4	1½	2	4	1	12½
Silt deposit for period		1,804	1,340	1,056	1,307	678	6.185
Silt per year, average		451	894	528	327	678	494
Total run-off		56,140	24,630	14,360	226,195	5,323	326,648
Percentage of silt in run-off		3.2	5.4	7.3	0.58	12.5	1.88
At Contour 990:							
Capacity	10,230	8,409	7,096	6,013	4,706	4,028	4,028
Percentage remaining of original capacity		82.3	69.2	58.8	46.0	39.3	39.3
Lost capacity per year in percentage of original		4.4	8.8	5.2	3.2	6.7	4.86
At Contour 1,000:							
Capacity	15,811	13,969	12,632	11,562	10,218	9,540	9,540
Percentage remaining of original capacity		88.1	80.0	73.1	64.6	60.3	60.3
Lost capacity per year in percentage of original		2.9	5.6	3.48	2.1	4.3	3.17

Life of reservoir, Contour 990 = 21 years. Spillway at Contour 991. Capacity between Contours 990 and 991 = 507 acre-ft.

Life of reservoir, Contour 1,000 = 32.4 years.

order to keep the valves clear, and some muddy water was drawn off for use on the fields.

It was estimated by the Engineer in Charge that each year during the third period, at least 50 acre-ft. of silt went to the fields and at least three times this quantity went back to the river, through the valves, with the waste water. How much has been carried out during the past four years, or what proportion of silt was in the water going out the waste-way, there are no records to show, but the quantity is not inconsiderable. (See Table I.)

Considering the reservoir at its present construction, the original capacity at Contour 990 (1 ft. below the present spillway lip), was 10,213 acre-ft. At the end of the first four years, it was 8,409 acre-ft., a loss of 4.4 per cent each year, leaving the capacity 82.3 per cent of the original. At the end of the next year and a half the capacity was 7,069 acre-ft., a loss of 8.8 per cent per annum, with 69.2 per cent of the capacity of the reservoir remaining. At the end of the third period (two years late), the capacity was 6,013 acre-ft., a loss of 5.2 per cent per annum. At the end of the next period, the capacity was 4,706 acre-ft., or only 46 per cent of what it had been 11½ years before; and, at the end of the last period, the capacity was only 4,028 acre-ft., 39.3 per cent of its original capacity. The average capacity lost each year was 4.86 per cent and the average lost per year for the entire 12½ years was 4.86 per cent.

Silt Deposits from Southwestern Streams.—The quantity of silt deposit shown by these measurements may seem to be very large to one who has not made a study of the streams of the arid Southwest, especially the ephemeral streams where there is little or no clear water run-off, the entire annual discharge being quick floods after the summer rains or in the spring when the snows of the higher elevations melt. Lake McMillan, in New Mexico, is reported to have silted up 60 per cent in 15 years. Taking the Zuni Reservoir at the 990-ft. contour, the percentage of filling would be about 70 in 15 years, and using the capacity of the reservoir at the 1,000-ft. contour, about 48 in the same time. In the reports concerning the Austin Dam, it is stated that in the 4 years, from 1893 to 1897, the reservoir was silted up 38 per cent of the original capacity, and during the period of 7 years, from 1893 to 1900, it had silted up 48 per cent.

Mr. W. W. Follett gives 1.66 as the mean percentage of silt carried by the Rio Grande, at San Marcial, N. Mex., from 1897 to 1912, inclusive. For the same period, the maximum was 4.14 per cent in 1911 and the minimum 0.78 per cent in 1905. He mentions the maximum for one day—Oct. 7, 1911—as 14.87 per cent and the monthly mean of 7.9 per cent for the month of October, 1911. It is probable that the maximum mentioned by Mr. Follett, namely, 14.87 per cent, would represent about the maximum quantity ordinarily carried in suspension. There are exceptions, as will be shown later.

Some experiments made by Rollin Ritter, Assoc. M. Am. Soc. C. E., Engineer in Charge of the Zuni Reservoir, leads him to the following conclusions regarding the silt-ladened waters of the Zuni River, and some general conclusions regarding the quantity of silt that may be transported in some of these southwestern streams. A report made by him in 1914, to the writer, contains the following statements:

The silt-ladened waters being heavier than the clear, ofttimes appeared at the tunnel outlet when the reservoir surface was clear and a small or moderate flood was entering the reservoir. During one period when the water wasted appeared very heavily charged with silt, a sample was taken at the tunnel outlet. This bottle test showed percentages of silt by volume at various times about as follows:

Time after collecting sample.	Apparent per cent of silt
1 day	55
7 days	35
1 month	25
3 months	17½
4 months	16

At the latter time, the silt in the bottle was compact and even showed lamination marks and probably no more shrinkage would have occurred. In the earlier periods when a sliver was plunged through the mouth of the bottle into the silt, the line of demarcation between the surface of the silt and supernatent clear water was not sensible to the touch. Unfortunately, the bottle containing the sample froze and burst, and the observations for a longer period could not be made.

The above may illustrate why so many engineers regard the bottle test as worthless. It may also explain why such enormous percentages have been reported at times from various sources, i. e., the silt as first observed will eventually shrink to one-third or even on-fourth the volume observed in the freshly gathered sample.

No tests are available to solve the question of how much was carried by the water in suspension, and how much rolled down the stream bed. The latter is, however, a large proportion of the former.

Some measurements made by the writer on Bonito Creek near Fort Defiance, Arizona, gave something over 13 per cent of sediment after the sample had stood 30 days. The most remarkable instance of large quantities of sediment carried by water was observed in the Moencopi Wash on the Painted Desert of Arizona. During a flood on this stream, a sample was dipped up from about the center of the thread of the stream and allowed to settle for two days, and remarkable as it may seem, at the end of that period, there was 15 per cent of turbid water and 85 per cent of sediment, showing that the flow of the stream was practically liquid mud. The sample was upset before it had time to settle further but it is probable that a settlement of 30 days would have shown not less than 50 per cent of solid matter.

Unfortunately, the Zuni Reservoir is situated in the bed of the stream, and all silt whether carried in suspension or rolled along the bottom of the stream bed is caught in the reservoir, except the comparatively small quantity that passes out through the valves, and the lighter portion of the sediment which is held in suspension and passes over the spillway at times when the water is flowing into the full reservoir. We have here a fairly large basin and a moderately high dam, and the entire closing up of the channel. "The greater the height of the dam or size of reservoir, the greater will be the rate of filling." This is the opinion of the late H. F. Labelle, M. Am. Soc. C. E., after an examination of the silt question in many reservoirs and behind many dams both in the United States and in India. It will be seen therefore, that in the case of this reservoir all conditions are favorable for the retention of large quantities of silt.

It is thought that 500 square miles closely represents the real area of the water-shed draining into the Zuni Reservoir. There are no records of the rainfall in this drainage area, and a study of the run-off divided into periods, shows that the precipitation is very irregular. During the two years, January, 1912, to January, 1914, the average run-off was less than 7,200 acre-feet, while from January, 1914, to January, 1918, the average run-off exceeded 56,000 acre-feet. It is probable that the average annual rainfall of the water shed is between 10 and 16 in., and until rainfall records are available on the water-shed, no relation between the rainfall and the run-off can be determined.

Quantity of Silt Carried by Stream. It is generally believed that the quantity of silt carried by any stream is largely in proportion of the magnitude of the floods, but according to the records at Zuni, little relation is found between the magnitude of the flow and the silt carried. During the period from 1906 to 1910, with an average annual run-off of more than 14,000 acre-feet, the percentage of silt deposit was 3.2. In the next year and a half, with an average run-off of 16,420 acre-feet, the silt deposit was 5.4 per cent. During the next period of two years, with a minimum run-off amounting to a little more than 7,000 acre-feet per year, the silt deposit was 7.3 per cent of the total, while in the last period of four years, with an average annual run off of more than 56,000 acre-feet, it was a little more than one-half of 1 per cent (0.58 per cent), and for the total period of 11½ years, the solids deposited from the run-off were 1.71 per cent.

In estimating the probable life of the reservoir, the percentage of silt in the run-off has been neglected, and the annual average quantity of silt actually deposited has been used.

In an article by Herman Stabler, M. Am. Soc. C. E., and Horatio M. Parker, regarding the silt carried by the Kaw River, they state that, in June, 1908, the river carried 41.4 per cent, and in May, June, July, and August 1908, 80.7 per cent of the total for two years. From this they deduce "The extraordinary influence of great floods, in erosion and denudation, is clearly shown." While this may be true of the flow of large rivers, it does not seem to be true in the case of the flashy streams of the Southwest, where the lesser volume of water in a year, coming in a few periods of run-off, seems to carry the greatest quantity of silt.

It has occurred to the writer that the great difference in the quantity of silt carried by the water may be explained, to a certain extent, by the fact that during the periods of lesser run-off the ground in the water-shed and the stream bed are very dry and, consequently, easily eroded by the floods, and that during the periods of greater run-off, more evenly distributed, the ground and the stream channels are kept moist and are, therefore, not subject to as great erosion during the beginning of heavy precipitation and run-off.

A remedy is not easily suggested. The situation involves a serious fact, not a theory, and at a very early date it will be necessary to put into practice some method of getting rid of the silt. Otherwise, a project built at a cost of more than $500,000, under which more than 3,500 acres are now being cultivated, and products valued at more than $68,000 raised last year by the Indians, will have to be abandoned inside of 20 years. It will be necessary to raise the spillway elevation within a year or two, for the entire capacity of the reservoir today is only slightly in excess of one year's need for the present area of cultivated land.

Remedial Measures for Silting.—Certain remedial measures have been suggested. One of these is to construct a set of small overflow dams in the stream above the reservoir. Even if these could be successfully constructed, and maintained at a reasonable cost, the silt accumulation of one year would fill a small one, and the ultimate filling of the main basin would be postponed only a short time.

It also has been suggested that much of the silt comes from the rapid cutting of the banks of the stream, and that rip-rapping these banks at the critical points would prevent further erosion and reduce the quantity of silt coming into the reservoir. The main stream is too long to make this feasible, and it has not been observed that the waters were any less heavily charged with silt at the head-waters of the feeder streams than in the main stream.

It also has been suggested that large sluices be installed at a low elevation, and the silt be gotten rid of in that manner; but observation in cases where dams have given way and the entire content of water run out through the opening, discloses that the quantity of silt sluiced out has been almost negligible.

The St. Johns Reservoir, in Arizona, the Austin Reservoir, and others, would indicate that a channel no wider than the opening, and extending back for a short distance, with almost vertical sides, would be the result.

The only plan that sounds at all feasible is that outlined roughly by the Consulting Engineer, J. H. Quinton, M. Am. Soc. C. E., when he was on the project some years ago.

This plan was to have a floating pipe line, connected with the lowest valve on the tower, now below the bottom of the reservoir. On a barge out in the lake, a cutter and nozzle were to be mounted, with a gasoline engine for power to operate the cutter, and a small vacuum pump. With a flow started through this pipe line, no power would be required to continue such flow other than the operation of the vacuum pump which would be placed at the highest point on the pipe line. What is really a suction dredge would thus be provided, and if all the water drawn from the reservoir was taken out in this manner, large quantities of silt could be removed.

Possible objections would be that in dry seasons there would not be sufficient water to waste, and all the water, heavily ladened with silt, would have to run into the canal, and, without a silt trap, it might fill up the two siphons in the canal. If it did not do this, much silt would be deposited in the canal and cause considerable expense and trouble for its removal.

Rainfall Records at St. Paul, Minn.—Records of the monthly and annual rainfall at St. Paul, Minn., since 1836 are given in the annual report of M. N. Goss, Commissioner of Public Works, for the year ending Dec. 31, 1918. The average annual rainfall for this 81-year period was 25.4 in., the averages by months being as follows:

	In.		In.
January	0.96	July	3.48
February	0.87	August	3.37
March	1.36	September	3.24
April	2.31	October	2.04
May	3.39	November	1.36
June	2.03	December	0.99

Points to Be Considered in Reconstruction of Small Water Power Plants

The very material increase in the cost of coal and fuel oils has brought home to the owner of a water power development the fact that he is a possessor of something of value. As a result he is giving it close attention and examination with a view of ascertaining if he is securing from his development all that can be obtained. In a paper in the recently issued Proceedings of the Michigan Engineering Society, Mr. R. K. Holland, Consulting Engineer, discusses this question and points out that the reconstruction of the plant presents something more of a problem than the purchase of a hydraulic turbine. Mr. Holland's paper, which considers particularly those water power developments that may be classed as small plants, with heads ranging from 8 to 20 ft. and with a contributary stream drainage area of 100 to 500 square miles, is given in abstract below:

These developments are principally for flour and feed mills, but there are a large number of hydroelectric developments, both private and municipal, and water works pumping plants driven by hydraulic turbines.

The owner, in looking over a water-power development that had been constructed prior to 8 or 10 years ago, generally feels, and correctly so, that the plant can be improved, but he is usually at a loss as to just how to go at it. He knows whether or not his present plant is sufficient in power to carry the usual load he imposes upon it, and he knows for what seasons of the year that he is very short of water, and what seasons he has plenty of water, and approximately the range of head that prevails. He knows the turbines are old and is aware that if he should purchase new wheels similar to those installed, he would undoubtedly receive more power, but when he makes an examination of the turbines he finds that the replacement of perhaps a broken gate and a little lining up of the shafts will give him, in appearance, a turbine which looks as serviceable as a new one. The consequence of all this is, that while he has a feeling that it ought to be reconstructed, he has not been satisfied that the reconstruction will show him a particular gain for his investment.

Engineer Must Study Conditions Influencing the Development.—If now we, as engineers, could be called in to examine such a plant, with the idea of putting before the owner concretely what his needs are and what the costs will be, we find that we must start deeper in the problem if we will obtain for the owner any particular advantage in reconstruction. We must go back first to study his plant and check up as to whether the original installation was suited to the stream and the purposes to which he proposes using it.

The question of whether the machinery installed is suitable or not for the speed at which he desires to operate and for the prevailing head, we can pass up for the present until study of the other considerations influencing the development is completed.

The stream flow is naturally of the most importance to the development and its determination is usually our first consideration.

The stream flow at a particular site may be determined by steam gagings or observations of flow over a dam of uniform crest and the like, but to be of any value the observation must extend over a considerable period of time. It is generally the case that there are no records of the particular stream at the particular site being considered. The engineer must then draw upon his accumulation of stream flow data of other streams, in the neighborhood if possible, having similar drainage basin characteristics, in order to estimate the probable flow of this particular stream at the site considered.

The judgment used in the selection of the records of known streams and their applicability to this drainage area is an all important factor in this approximation of stream flow. It is to be particularly noted that 3 or 4 stream observations at this site, unless they be selected at extreme conditions and at average conditions, are of very little value in arriving at what might be the average flow of the stream in the course of a number of years.

Assuming that we have arrived now at the average flow of the stream, the next point to consider is the head under which the turbines will operate. The head, as we use it, is the distance from the average water surface level in the wheel pits to the average surface level of the water in the draft pit, or in case a curve draft tube is used discharging the water down-stream, to the water surface at the exit of this draft tube.

Factors Influencing Head.—The two particular factors, therefore, influencing the head are the level of the water surface of the pond and of the tail race. The pond level is subject to variation due to the stream flow being less, or in excess of that used by the turbines. The excess is taken care of usually by flood gates or spillway, and the pond is generally at its highest level during such periods. When the river flow is less than the water used by the turbines, there is a draft on the pound and the water is pulled down.

The highest stage that the pond may be carried is generally controlled by the flowage rights and in each case requires investigation as to whether there are physical limitations to a higher pond stage, that is to say, whether the raising of the pond level will cause very large flat areas to be flowed, or is prevented by the physical conditions at the dam or plant. If no such limitations are present, it is usually advantageous to the owner to acquire flowage for a higher pond level, and it can be usually shown that this flowage is worth much more to the owner than he has assumed it to be, when he has considered it worth only the value of the adjacent property for farming purposes.

The tail water level is generally the level of the natural river before the development, and if there are no obstructions immediately below the plant, usually no particular advantage to the head may be gained by improvement to the tail race, such as deepening and the like.

Effect of Raising Pond on Backwater Situation.—There is one factor usually present in the question of raising the pond that is little understood, and that is the question of backwater, meaning by backwater, the increase of the water stage due to the construction of the dam, over the water stage of the natural stream. With any dam constructed across a stream and with a normal stream flow and the pond level carried at the crest of the spillway, the maximum backwater effect will occur at a point located approximately at the intersection of planes tangent to the water surface of the pond and to the water surface of the stream above the pond. If the pond surface is now maintained at the crest of the dam, with increasing stream flow, the backwater effect will usually become less and with decreasing flow becomes greater at this point, but if the spillway is of ample discharge capacity so that the head on the spillway for the overflow, increases at a lesser rate than the normal river stage for the same increased flow of water, the backwater effect at the point first considered becomes no greater with this increasing flow, when such increase of flow is wasted over the spillway.

While it may be found that the amount of the backwater effect is less with the increased flow being wasted over the spillway, at the same time it may be also found that the backwater effect reaches further upstream. Usually this is of little importance because of the small amount of the increase of river stage, but should this back against another water-power development this small amount of backwater effect frequently causes a large amount of trouble.

The engineer should make a careful study and endeavor in such cases to clearly present the problem so that it may be understood by the interested parties and if possible form the basis of an agreement whereby the lower development may back water against the upper under the extreme conditions, thereby obtaining between the two plants the maximum power obtainable from the river.

Uses for Power.—The use to which the power is to be put is our next consideration. If for milling or manufacturing it is generally required for 9 or 10 hours each working day, sometimes for the 24 hours. If for hydroelectric developments with a single plant power may be required for 24 hours but sometimes is required for only 10 or 12 hours, this usually where commercial lighting only is served, or for lighting and pumping, where a reservoir or elevated tank is available.

In reconstruction, this matter is more or less definitely settled by the past performance at the plant, and the gain in power output from the higher efficiency usually provides a margin that insures the turbine being of sufficient capacity to care for peak periods.

Where a change in the length of period of operation or additional load is contemplated, particular attention must be given to the probable power obtainable at the site in order to advise whether the development will permit the change.

The capacity of the pond (in acre feet) is the factor which determines the ratio of the maximum power of the daily period to the average 24 hour power available from the river flow.

An acre foot being the quantity in an acre of water 1 ft. deep, the capacity of the pond is then dependent upon the product of the average area and depth of draft to which the pond may be drawn. The area being fixed by physical conditions the capacity is directly dependent on the draft. But the draft on the pond reduces the head on the turbine and results in a power loss that increases at better than three halves power of the ratio of the change of head, consequently a minimum draft is desirable. From practical considerations 5 to 8 per cent of the head may be permitted as the draft on the pond.

Pulling Down the Pond.—This question of pulling down the pond is one that the engineer should cover thoroughly with the owners of the development, as the usual rule is to find that the operators of the plant pull the head excessively at the beginning of the summer season and it is not given an opportunity to recover again until the fall rains, resulting in shortage of power during the whole summer. We find this condition usual with municipally operated plants and only little less frequent with privately owned plants. One plant, a year or so ago, whose average head is 15 ft. pulled the pond in the first three summer weeks to between 9 and 10 ft. and operated at these low heads all summer by generating some auxiliary power by steam and cutting short the street lighting period. The plant capacity at these lower heads for the same amount of water was less than one-half the capacity at the full head, and had the auxiliary power been supplied when the head started lowering, auxiliary power would probably only have been required the first week of the summer period. Best rule is perhaps to have the pond brought to normal stage at least once in 24 hours.

The ratio of the turbine capacity to the normal stream flow is determined as is shown above from the considerations of the load to be carried and the size of the pond, and the permissible draft on the pond.

Deciding on Capacity of Turbine.—We have now gotten the elements together that permit our decision as to the capacity of the turbines to be installed. By reference to our determination of the river flow we can select the point from the expected average annual stream flow that will give us the most economy in the relation of the cost to the power obtained. Naturally, if the installation is made equal to the minimum continuous flow, we would obtain the most power for the least money invested in machinery only, but because of the investment in the powerhouse, dam, flowage rights, etc., we usually find that the economical development in most cases will occur at a point in the stream flow that may be said to be just above the average normal flow of the stream. Applying to the quantity of water that this point represents, the head that will prevail for this quantity of water flowing, we can obtain the theoretical 24 hour power of the development, to which must be then applied the factor previously determined by the use to which the power is to be put, resulting in the theoretical capacity to be installed.

If this be taken roughly at 70 per cent to 75 per cent efficiency, the approximate plant capacity is obtained, which may be checked against the power required for the operations, and adjusted, if necessary, to meet the actual conditions that prevail. This adjustment, however, is usually at a sacrifice of the power that the stream produces. This being true from the fact that if a much larger installation is made, the efficiency of operation is less because of the necessity of running at small gate openings for longer periods, and if a much smaller turbine is installed, the possibility of not being able to carry the peak load becomes pertinent.

Selection of Turbine.—As is generally known, a turbine of a given runner characteristic will have a practically fixed speed for a given head for each of the manufacturer's size of turbines, and it is necessary here to make adjustments and concessions between the capacity of the wheel or wheels and speed at which these wheels are to operate. The higher the speed, of course, the smaller the individual turbine. With hydroelectric developments this problem is usually complicated further by the fixed speed requirements of an alternating current generator, and with any development it is usually necessary that the speed selected be maintained constant, notwithstanding the variations of head that will occur.

It is, therefore, necessary that the engineer, in making the selection of the turbine, be conversant with the type characteristics and the standard capacities of the manufacturers' developed turbines and co-ordinate the number of turbines and the speed to the total capacity which is now practically fixed, to obtain the maximum power under the variations of head and load usually prevailing.

Aside from the runner characteristic of the turbine to be selected, some consideration must be given to the mechanical construction of the turbine, so far as relates to the shop work, strength and rigidity. These being more important where the turbine is to be operated on an extremely variable load, with the gates controlled by oil pressure governors.

Having selected the turbine a computation of the probable annual output may be made, which combined with the fixed and operating cost forms a criterion from which the owner may arrive at a decision as to the necessity of reconstruction.

Details Affecting Operation of Plant.—There are numerous minor details now to be considered relating principally to those affecting the operating of the plant.

If the power to be used for milling and for general manufacturing purposes, the so-called friction governors are generally satisfactory, but if for hydroelectric work, it is usually necessary to have the more sensitive oil pressure governors. The question of bearings and the supporting of the runner and shaft is more important than the consideration usually given, because these points are the ones continually under the observation of the operator, and where no trouble is experienced, he has faith in his machinery and does all in his power to keep it in first class condition, while, if he is continually having trouble with alignment of shafts and with bearings, he is very apt to become convinced that the entire equipment is no good, with the result that he does not give it the attention that it should have to deliver the power of which it is capable. This is a point that is frequently lost sight of, and is a particularly important one from the owner's point of view.

The structure to house the equipment is controlled primarily by space required for the machinery on the operating floor and by the requirement of ample water passages to and from the turbine, and secondarily, by the relation of the structure to existing structures, bridges, the channel, and the like.

The powerhouse construction itself does not differ materially from other first class constructions except the requirement of water tightness, rigidity of construction and the necessity of providing that no settlement takes place. Special caution must be observed, however, that foundations are protected against undermining, as a small spurt of water at a critical point will very quickly wreck the best hydraulic structure.

The shape of the flume and location of the turbine in the flume requires special study, if for any reason that water area to the turbine is to be restricted. Trash racks and easily operated wheel pit gates are necessities to a well designed plant, particularly the desirability of easy and quick operation of the head gates by the operator, as they serve as an inducement to him to the making of periodical inspections of the turbines and under-water mechanisms.

Unless the head is very low the turbine is invariably placed above the tail water level, making the question of the draft tube a particularly important one, and not of easy solution even where the engineer has wide latitude in his design. Where space is restricted, the design of the draft tube must be governed largely by the designer's experience and the results obtained from other constructions where conditions analogous to those under consideration are present.

Examples of Small Plant Reconstruction.—As a result of the practical application of the principle of making a study of the small plant reconstruction along lines very similar to those followed with a larger installation, I would cite the folowing reconstructions of this type made by our firm in the last couple of years:

In a hydroelectric plant in the northern part of Michigan, drainage area about 100 square miles, normal head about 14 ft., the old installation was a single turbine some 20 years old, rated at 170 hp. apparently in good shape except that the runner had the edges of the buckets bent from debris going through the gates. The turbine was gear-connected to a line-shaft some 15 ft. long, running at about twice the speed of the turbine from which a 150 kw. generator was belt-driven. The plant operated only on night load. This equipment was replaced by a single directly connected turbine and generator unit of 100 kw. capacity, the rating of the turbine being slightly smaller than the original turbine and running at about 60 per cent greater speed. The plant is carrying from 2 to 4 times the load previously carried, and at no time within the last two years has the plant been short of water, as had been the case each mid-summer and mid-winter season previous.

A hydroelectric plant in the central part of Michigan, drainage area 500 square miles, 14 ft. head formerly consisted of two turbines, each one gear connected to two short horizonal line-shafts from each of which was driven a generator. There were two outgoing feeders from the plant and the load of both feeders was sometimes carried on the larger of the two generators, and at other times the units ran separately, one to each feeder. The reconstruction here was caused by the undermining of the foundation resulting in a collapse of the powerhouse. The equipment of the new powerhouse was in two units, each consisting of a directly connected turbine and generator, the one unit being approximately one-half the capacity of the other, permitting power to be produced at high efficiency from about one-sixth to full capacity of the plant. The load on the plant has been approximately tripled since the old plant went out of service and no shortage of water has been experienced within the last two years of operation

A hydroelectric plant consisting of two turbines, gear connected to a horizontal shaft about 20 ft. long, to the end of which was directly connected a horizontal shaft, slow speed generator of 350 kw. capacity, and to which was also belted a steam engine. One turbine, the gears and part of the horizontal shaft were removed, and a vertical shaft, directly connected generator unit installed with a turbine capacity slightly larger than one of the original turbine. Upon completion of the work the load was thrown from the remaining gear-driven unit, to the new unit and 100 per cent additional load thrown on, and after shutting down the old unit the surface of the water in the tail race dropped about 4 in. due to the decreased discharge through the new turbine, even when carrying double load of the old one.

An industrial plant requiring power 9 hours, three old turbines were removed and replaced by one vertical shaft turbine, gear-connected to a mill with the turbine selected for proper speed for connection to a future alternating current, vertical shaft generator. The new unit, although slightly larger than larger turbine of the old installation, is carrying at about two-thirds capacity, the entire mill equipment, which has been materially increased over the installation which the old turbines could just carry.

Maintaining Tight Boiler Settings Cuts Fuel Banking Costs

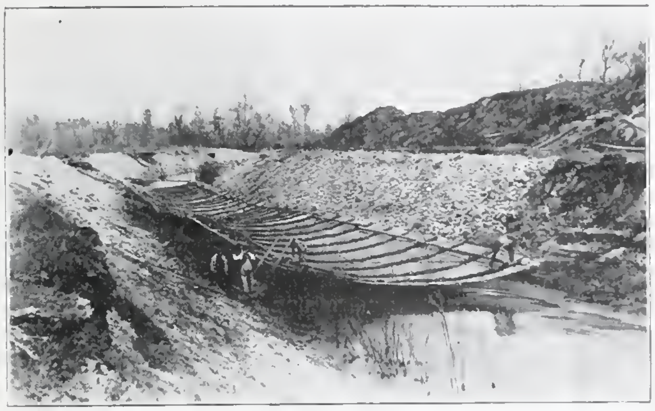
When the last generator of the Waco plant of the Texas Power & Light Co. is shut down at 10:30 p. m. the boilers are filled with water to within 1 in. of the top of the gage glass. Fires are left burning during this time and steam pressure is raised to the "popping-off" point, which is 210 lb. The coal feed to the stokers is cut off, and all ash-pit doors are closed tightly. The boilers are then left in this condition until 15 minutes of starting-up time, which is 6:30 a. m. Generally the steam pressure drops to 125 lb. during this period, and calculations from daily reports show that the amount of fuel for bringing one 600-HP. boiler from 125 lb. to 200 lb. is only one barrel of oil.

When this system was first adopted, states the Electrical World, the engineers of the company thought that there would be considerable delay in starting up, caused by the low steam pressure, but it was found in cases of trouble the fireman is always able to raise his steam to operating pressure before the engineer can get the vacuum pumps and circulating pumps started. In this plant the fuel-banking costs were cut from $12 to $50 for each 8-hour period. This could only be accomplished by covering the settings with asbestos plastic, keeping the blow-off valves, feed-water valves and superheater drains tight and maintaining close-fitting dampers and ash-pit doors.

Board Mattress for Preventing Scour in Drainage Channel

By B. F. BURNS.

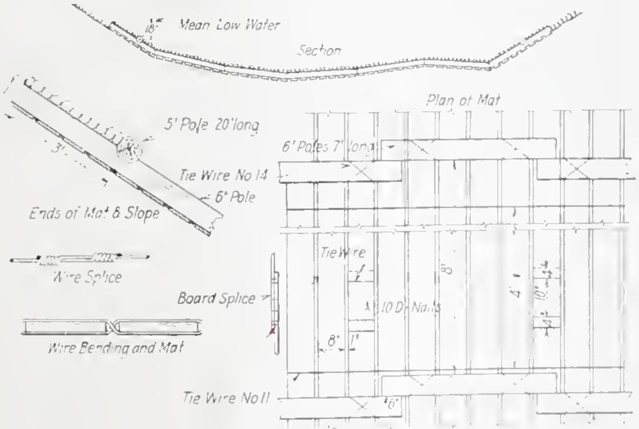
An essential part of the drainage plan of The Little River Drainage District of Missouri is its headwater diversion system, a series of artificial canals and improved river channels constructed and utilized for the purpose of carrying the waters of the hill streams eastward into the Mississippi River just below Cape Girardeau, Mo. Below these, natural barriers are utilized, and levees are constructed to prevent the flood waters from the streams mentioned passing down over the area below which it is the purpose of the district to drain.



Board Mattress Ready for Stone.

In the construction of the headwater diversion system three large basins are formed, having a combined area of about 23 square miles, for the purpose of storing the flood waters and retarding the flood movement to such an extent that the works may not be overtaxed. These basins are not mechanically controlled, but the design intends that they shall operate in such order and at such time that the flood crest will have passed at the middle basin before the flow from the west basin reaches its maximum. As a means of controlling the flow from the west basin the channel at its east end was decreased in size.

It was known that the channel there would develop high velocities, and before the work was finished and the diversion of the main stream to the westward effected, the channel was paved along the slopes with stone for a reach of almost a quarter of a mile, to prevent enlargement of the channel by scour.



Plan, Section and Details of Board Mattress.

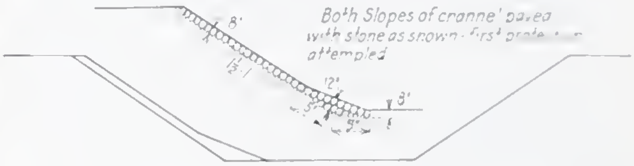
The first real test of the works came in May, 1918, with the system not quite complete. During December of the year another flood passed through and, while of not so great magnitude as the former one, it afforded an opportunity for observation and study.

It was found that the velocities developed through the restricted reach were too great for the material in the bottom of the channel to stand and the material was eroding so badly that further protection was necessary.

It was decided to attempt to hold the upper 300 ft. of the channel by covering the bottom of it with a wooden mat weighted down with stone and a mat was designed to be constructed of 1-in. x 8-in. boards, laid parallel with the center line of the channel, laced together with wire and with poles not less than 6-in. diameter placed transversely at intervals of 8 ft. to prevent the movement of the stone.

How to construct the mat, whether in part or as a whole and where to construct it so that it could be placed intact was a problem. It was finally decided to construct it as a whole suspended over the channel, and when complete drop it into place.

Following this plan, No 4 wires were strung across the channel at 5 ft. intervals and securely fastened to deadmen on each side. The mat was then constructed by nailing together the boards until a unit 50 ft. long was made. This was placed on the wires and as rapidly as other units were completed they were laced together with wire, making a half turn between each. After the section of the mat was completed, the next section was begun and the work carried on in that manner until the entire mat was completed. The transverse poles were then placed and tied and then the longitudinal poles were put on. This being completed and the mat anchored by lacing a cable through it at the upper end to prevent it from moving down the channel when dropped, loading the upper end with stone was begun. A single row of heavy stones across the end and a few scattered over the first panel was all that the suspension wires would stand and those at the end elongated to such an extent that the mat dipped water. The velocity was so great that the water immediately began to pour over the surface of the mat to such an extent that it was thought best to cut the suspension wires and let the mat down into place.


Both Slopes of channel paved with stone as shown - first protection attempted
8'
1½:1
12"
3'
3'
9"

Stone Paving on Both Slopes as First Attempt to Prevent Scour

The completed mat was 10 ft. wide on the average. The lumber was obtained from a mill in the vicinity of the work, the poles were cut along the channel and the stone quarried about ¾ mile from the site. Owing to the inexperience of local contractors in work of that nature, the work was done on a cost plus basis. A commissary was established for feeding the workmen and temporary housing quarters erected. Including all of the expense and some repair work made necessary by reason of the damage by flood before the loading was completed, the mat was constructed at a cost of approximately $12.00 per linear foot.

Lowering Mattress into Channel.

Mr. L. L. Hidinger, of the Morgan Engineering Co., Memphis, Tenn., is chief engineer of the Little River Drainage District.

Engineers for U. S. Reclamation Service.—Applications are being received by the U. S. Civil Service Commission, Washington, D. C., for examination for the following positions in the U. S. Reclamation Service: Engineers, $3,000 per year; assistant engineer, $1,800 to $2,880; junior engineer, $1,200 to $1,740; engineering draftsman, $1,200 to $3,000.

Sewage Treatment at English Military Camps

In a discussion of the paper of Major Leonard S. Doten, on "Sewage and Wastes Disposals for the U. S. Army," presented before the American Society of Civil Engineers (see Engineering and Contracting, Aug. 13, 1919), G. Bertram Kenshaw, Consulting Engineer, London, England, presents in the August Proceedings of the society, some interesting information on his experiences in sewage disposal at the military camps in Great Britain.

For purposes of comparison he gives figures of analysis for an ordinary domestic sewage and for a barracks sewage, the latter in Great Britain differing but little from camp sewage. The following figures relate to the average of three sets of hourly samples. taken at the Aldershot Camp Sewage Farm:

	Parts per 100,000.	Parts per 1,000,000.
Ammoniacal nitrogen	7.87	78.7
Total organic nitrogen	5.06	50.6
Albumenoid nitrogen	1.62	16.2
Total nitrogen	13.3	133.
Oxygen absorbed in 4 hours	20.79	207.9
Chlorine	14.98	149.8
Suspended solids	36.6	366.

The Caterham Barracks figures were obtained from the average of four sets of hourly samples, and are even stronger:

	Parts per 100,000.	Parts per 1,000,000.
Ammoniacal nitrogen	31.41	314.1
Albumenoid nitrogen	1.75	17.5
Total organic nitrogen	3.87	38.7
Total nitrogen	17.53	175.3
Oxygen absorbed in 4 hours	17.99	179.9
Chlorine	13.57	135.7
Suspended solids	42.10	421.

The sewage of Kingston-on-Thames may be regarded as an average domestic sewage, and the figures are also obtained from sets of hourly samples, drawn according to rate of flow:

	Parts per 100,000.	Parts per 1,000,000.
Ammoniacal nitrogen	3.85	38.5
Albumenoid nitrogen	0.86	8.6
Total organic nitrogen	1.63	16.3
Total nitrogen	5.49	54.9
Oxygen absorbed in 4 hours	10.66	106.6
Chlorine	9.43	94.3
Suspended solids	31.	310.

The foregoing figures demonstrate the strength in nitrogenous matter of camp sewages as compared with domestic sewages, and this is due no doubt to the fact that the population is adult, and, further, the quantity of nitrogenous food consumed is large. The same thing has been observed in Great Britain, in the case of colliery towns and villages; in these cases, however, the water supply is often low.

During the first stage of the war, considerable difficulty was experienced with grease, and specially large grease traps were put into use for intercepting it. Disinfectants, too, were often used in sufficient quantity to interfere materially with biological purification. Grease, however, was the chief difficulty, and, as might have been anticipated, it caused trouble at all stages of treatment, while it was some little time before steps were taken to utilize the grease recovered.

In the early stages of the war, many of the camp sewage treatment works left a great deal to be desired, both as regards design, and ability to cope with the very concentrated sewages. Moreover, in some instances, several small treatment works were constructed, where, with a little ordinary engineering skill, one plant would have sufficed.

In the camps in Great Britain, it was found that the sewage flow was almost invariably divided into distinct flushes, the flow being practically confined to about from 10 to 12 hours out of the 24. Consequently, when the filter capacity was calculated on the basis of the sewage flow of an ordinary town, at a rate of, say, 75 gal. per cubic yard per 24 hours, it was about 50 per cent too small. This fact was often lost sight of at first.

With respect to water supply per capita, the figures given by the military authorities were usually found to be much too low, and 30 gal. per head was determined as being about right, in fact, it was the usual figure taken for a town water supply.

With regard to manholes, it is the customary rule in England, that the distance apart shall not be in excess of about 300 ft. Some years ago, lampholes were permitted between the manholes, but, lately, they have been discouraged by the Local Government Board. In the case of the majority of the camps, full treatment by tanks and filters has been carried out, as conditions were seldom such as to warrant the discharge of tank liquors without further treatment.

The following details of a plant designed to deal with a total sewage flow of about 20,000 gal. per day, may be instructive, as showing that the treatment of a strong camp sewage is by no means a simple matter:

1. Grease trap.
2. Covered septic tank, capacity about 15,000 gal., with inverted pyramid bottom for removal of sludge.
3. Small mixing tank for chemicals.
4. Four fill and draw settling tanks, capacity of each about 5,000 gal., with floating arms and sludge valves.
5. Two dosing tanks, capacity of each about 200 gal.
6. Two deep percolating filters of coarse coke or clinker, capacity of each about 250 cu. yd., with automatic distributors.
7. Effluent settling tank, capacity about 2,000 gal., with inverted pyramid bottom for removal of humus.
8. General sludge sump, provided with chain-pump, and communicating with septic tank, settling tanks, and effluent settling tank.
9. Two shallow effluent straining filters of fine coke or clinker, each about 20 sq. yd. in area and 9 in. deep.
10. An area of land set aside for trenching the sludge, which would be considerable in volume.

This is a specification written by Maj. C. C. Frye, one of the chemists to the recent Royal Commission on Sewage Disposal.

Comparison of the work done even by similar filters, with similar distribution, is beset with pitfalls. For example, a 5-ft. filter (A), may be working below its full power and producing a good effluent at a certain rate of filtration per cubic yard; it would be erroneous to dose a 10-ft. filter (B,) at a rate three times that of Filter A, and, because it produces an effluent similar to that of Filter A, to assume that Filter B can treat three times as much as Filter A, as Filter A is not working up to its full capacity; this destroys any comparison.

Concerning continuous and intermittent distribution on filters, it is to be observed that if the tank liquor is applied to filters not continuously, but in flushes, this must result—other things being equal—in increasing the volume treated per cubic yard in a given time. It would seem to be most desirable, in comparisons of treatment plants, to give the numerical figure of strength of sewage dealt with in each case.

Unionization of Technical Men in France and England

In a recent address before the Chicago local of the International Federation of Technical Engineers, Architects and Draftsmen's Unions, Mr. Anthony J. Oliver, international president, stated that in France and Italy and in Great Britain the scientific and technical men were organizing as a branch of organized labor. The secretary of the French-Italian group announces their platform to be as follows:

"We demand the creation of a national and economic council which shall include representatives of all the three forces which collaborate in production, labor, capital and technical skill. We want this council to be not a mere debating society but a national organization whose advice will be solicited in all important questions of national economy and whose resolutions will have decisive weight."

In Great Britain a similar organization was formed, known as the Society of Technical Engineers. It is a union of brain workers, beginning with engineers and extending in time to all ranks of qualified men, including doctors, scientists and chemists, and embraces buyers, experts and managers of business and industries. Employers are not eligible. By the latest reports and statistics it is calculated that at least 500,000 men are coming within the scope of this new union. There is to be no interference, however, with existing societies. It aims at giving the men whose knowledge is essential to the success of every great enterprise, a voice in all disputes and a place in all industrial councils.

New Well Supply of Minot, N. Dak.

Until October, 1916, the city of Minot, N. Dak., with a population of about 16,000, had always taken its water supply from the Mouse River. This water having become unsatisfactory because of its hardness, impurity and quantity, an investigation of sources and possible means of securing a larger and better supply was begun under the direction of Frederic Bass, Consulting Engineer. The following account of this work is abstracted from a paper by Augustus Hunt in the August Bulletin of the Affiliated Engineering Societies of Minnesota.

The following sources of supply were considered: Moderately deep drilled wells, springs in the hills to the north of the city and batteries of shallow wells or infiltration galleries.

Minot is located outside of the artesian basin of the Dakotas, on the western edge of which is located the City of Aberdeen, in South Dakota, so that the securing of water from such a source was out of the question. Investigation of the water found in the springs along the hills north of the city showed the water to be very hard and also limited in quantity. Shallow wells gave a potable water, but a very elaborate system would be necessary to procure the desired quantity, so the cost of construction would be very high. To ascertain the quality of water and the character of the underlying strata, 6 2½-in. wells, ranging in depth from 30 to 60 ft., were jetted down.

Moderately deep drilled wells were next investigated. Two 4-in. wells drilled in the valley showed the existence of coarse gravel at a depth of 115 to 138 ft., but caving and the encountering of large stones when drilling failed to give satisfactory information and the quantities of water obtained were small. Two 5-in. wells were therefore drilled in selected locations. These wells showed a fair quality of water and a similar gravel strata but the quantity of water that could be pumped from them seemed far below the amount that should have been obtained. The punching of slots in the well casing was tried. Also a brass perforated well screen was secured and pumping tests made. A greater quantity of water was obtained by the use of the screen. The pumps used were of the plunger type and were supplied by the well driller who used his driller engine to operate them.

To determine the extent of the gravel vein to the south, a 10-in. well was drilled at the southern edge of the valley. Gravel was encountered at a depth of 120 ft., but after passing from the gravel vein at 135 ft. a dense clay strata was entered showing a thinning of the gravel vein at the valley edge. A pumping test on this well gave 100 gal. per minute. The water, however, contained a large quantity of alkali and was not to be compared with the water obtained from the 4 and 5-inch wells located nearer the center of the valley.

It might be well to state here that a log was kept of each well and a sample was taken at every foot during the drilling, so that data for comparison and record was at hand.

Mr. Howard Simpson of the University of North Dakota, who was retained as consulting geologist, at this time advised that a series of test wells be drilled to the north across the valley perpendicular to the underflow, it being anticipated that somewhere in the coarse gravel a much larger stream of water was flowing underground than had been encountered in any of the wells. The gravel in the valley is of glacial origin, having been deposited ages ago when the valley was much deeper and was later covered by the sand and clay brought down from the upper courses of the river during the period when the glaciers were receding.

As well number 8, located the furthest north of all the wells, showed the thickest gravel vein and produced the largest quantity of water, for its size, of any of the wells, it was determined to put down the next well 90 ft. to the north. This well, known as No. 13, indicated a course vein from a depth of 85 ft. to 132 ft. below the surface. The water in the well rose to within 10 ft. of the surface of the ground and 12 ft. higher than the water level in the river. A Johnson brass well screen, 9 in. in diameter and 40 ft. long, was installed and the well, upon pumping, gave the remarkable flow of 890 gal. per minute (1,500,000 gal. per day), a much greater volume of water than has ever been obtained from any well in North Dakota, and which even approaches the flows from some of the artesian wells in the states to the south and east.

A pumping test was made covering a period of 48 hours at the rate of 890 gal. per minute. The water at the end of that time was lowered only 7½ ft. and its level was quickly restored when the pumping was stopped. For a period of one half hour, 1,400 gal. per minute was pumped but as the pump was not capable of maintaining a very high speed, it was not attempted to continue pumping at that rate. The drilling of the well, placing of the screen and the conducting of the pumping test was done under a contract with the McCarthy Well Co., of Minneapolis.

After the pumping test was completed the city waterworks department installed a 7-in. centrifugal pump and pumped the new water directly into the city mains. This was a temporary arrangement to allow the water users to sample the water, but was also a step of expedience, as considerable difficulty was being experienced at the intake of the old pumping plant, due to the low head of water in the river during the fall and the possibility of the intake freezing during the approaching winter.

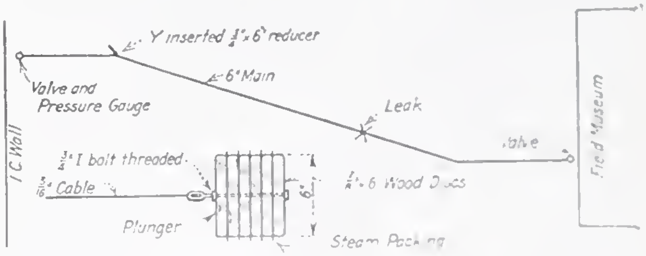
The quality of the new well water is far superior to any well waters heretofore obtained in the state of North Dakota. Its softness approximates that of rain water and it is free from alkalis and other undesirable constituents. It has been estimated that its softness will save the water users about $5,000 annually. There is a slight color to the water due to organic extractives, which, however, are perfectly harmless and it has been noticed that the color has decreased somewhat since the initial pumping. Bacteriologically the water is pure and analysis shows it to be very desirable. Also, it is suitable for boiler use, for which purpose it far surpasses the filtered river water. The former cost of filtering and treating the river water has amounted to $6,000 per year. This cost will be eliminated in using the well water.

General plans for the improvement of the entire water system have been made and individual units and special features of the new system are being constructed as money becomes available.

Method of Finding Leak in Pipe Under 30-Ft. Fill

An ingenious method employed in locating a leak in a 6-in. water main buried under a 30-ft. fill in front of the new Field Museum in Chicago, is described as follows in Successful Methods:

The water was cut off at the valve near the Illinois Central right of way retaining wall shown in the figure. The pipe was cut and a Y laid on its back was inserted, through which the diaphragm plunger shown in the figure was passed. This plunger was made of six 1-in. discs with rubber steam packing between and a threaded eye bolt run through the center to which a 5-16-in. wire cable was attached. The end of this cable was first threaded through a ¾ by 6 in. reducing bushing with the ¾-in. opening packed to make a water tight joint around the cable, after which the reducer was placed in the open end of the Y. A pressure gauge was put in at the valve near the Illinois Central wall.



Sketch Showing How the Leak Was Located.

Water was turned on, the valve at the building closed and about 6-lb. pressure obtained in the pipe by opening slightly the valve at the Illinois Central wall. The plunger moved along the inside of the main until the leak was reached, when the pressure disappeared and the plunger stopped moving. This located the leak, the distance from the Y being determined simply by measuring the cable as it was paid out. The plunger stuck once or twice, necessitating an increase of the pressure to 18 lb. until it started again.

The method was devised by Howard White of Graham, Anderson, Probst & White, architects of Chicago, and was executed by R. J. Powers, the plumbing contractor.

Dam and Tunnel Construction by the Marin Water District

A water supply development of considerable interest which has just been completed is that of the Marin Municipal Water District in Marin county, California.

The district, which includes a number of communities, was organized in 1912 for the development of a common water supply system. Extensive studies of existing and other sources of supply were made which led to the conclusion that the watershed of Lagunitas Lake, with an area of 10 square miles, could be developed to provide a daily draft of 15,000,000 gal., sufficient for 50 or 60 years.

The project, which involved the construction of a dam, tunnel and pipe lines, is described by H. M. Bowers, assistant engineer, in recent issues of the Journal of Electricity.

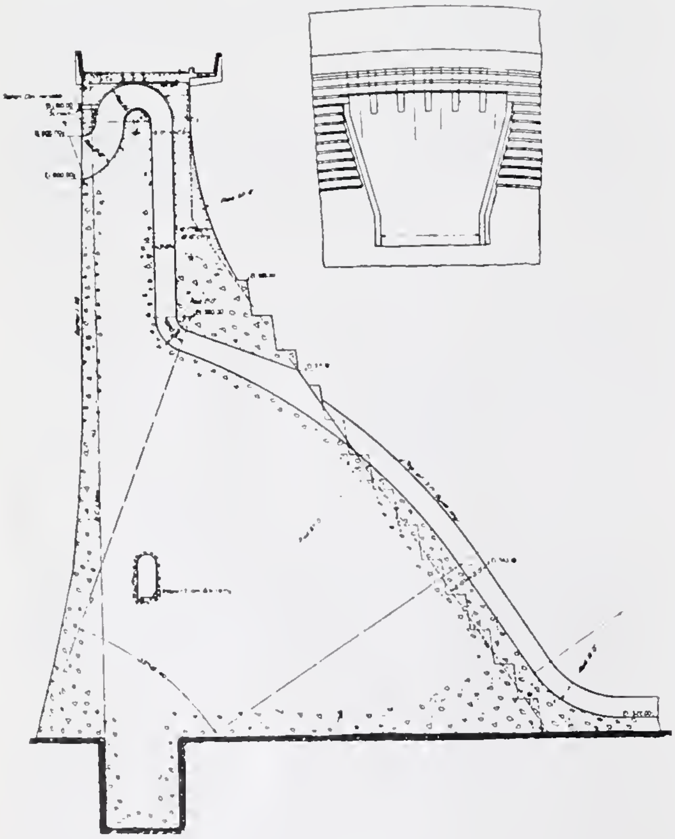
Gravity Type Dam.—The dam, which is of the gravity type, is 10 ft. high, 350 ft. along the crest, and is curved in plan to radius of 465 ft. It contains 27,700 cu. yd. of concrete in mixtures of 1:2½:5 and 1:3½:7. On the upstream face 6 lb. of hydrated lime was used with each sack of cement.

The intake tower is semicircular in plan, built monolithic with and against the upstream face of the dam.

Water enters the tower through three sets of 18 in. circular sluice gates placed at different elevations. A fourth set is placed at the bottom to permit draining the reservoir.

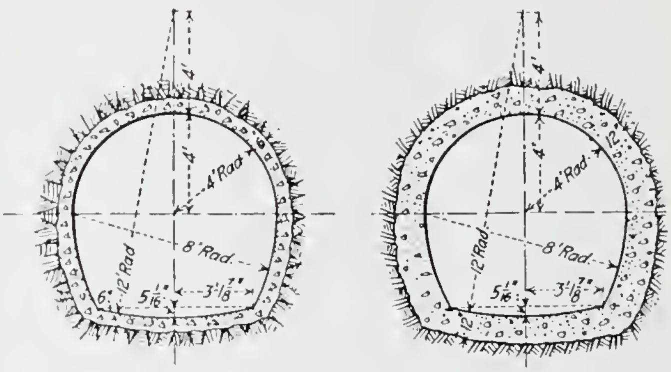
Siphon Spillway of Dam.—A rather unusual feature of the dam is the siphon spillway designed to discharge 4,000 cu. ft. per second. Conditions at the site of the dam precluded the use of any of the usual types. The banks were steep, the valley narrow, and a roadway across the top was necessary.

The consideration of the siphon showed that six siphons, each 3x7½ ft. in cross section, with downstream legs of such length as to utilize full atmospheric pressure, would readily discharge the quantity of water for which it was necessary to provide. The six siphons were located in the central portion of the dam with 3 ft. of partition wall between adjacent ones, thus making the portion of the dam affected by them only 60 ft. in length. The siphons discharge between two guide walls running down the back of the dam, converging somewhat toward the lower toe and discharging the water into the bed of the creek at its lowest point. The crest of the siphons is only 5 ft. below the crest of the dam, thus saving nearly all of the reservoir capacity. No difficulty was found in supporting the roadway over the siphons as the spans of 7½ ft. were provided for by reinforcing steel bars, except at the thinnest portion in the crown, where three 18-in. I-beams were embedded. Each siphon is provided with two air vents, 6 by 24 in., leading from the face of the dam into siphon chamber at the elevation of the siphon crest.



Profile View of Dam Showing Siphons.

Other features of the dam are an upper inspection gallery 4 by 7 ft., inclined and lower galleries 3 by 6 ft., drainage wells spaced 10 ft. apart, three contraction joints, grout holes and pipes. Two rows of staggered grout holes, the holes in each row being 15 ft. apart, were drilled into the bed rock along the cutoff trench. From the tops of these holes iron pipes are led to the inspection galleries. No grouting of these holes was done during the construction but they provide a ready means of so doing should the occasion demand.



Sections of Tunnel.

Rock was obtained from the hillside. Part of it was crushed into sand on account of high costs of hauling.

Labor Costs of Pine Mountain Tunnel.—The Pine Mountain tunnel, as it is known, is 8,700 ft. long. It has a cross section of horseshoe shape and a net area of about 54 sq. ft. Labor costs on the tunnel were kept by the resident engineer from whose memoranda it appears that the cost of labor alone for excavating and timbering (about 25 per cent of the tunnel required some timbering) was $14.18 per lineal foot, and that the cost of lining was $5.07 per lineal foot, making the cost of labor for both excavation and lining 19.25 per lineal foot. The average cost of labor for timbering was $1.85 per lineal foot for the entire tunnel, but for the portion actually timbered the cost was $7.55 per lineal foot. Rock for the concrete lining was quarried and crushed at the east portal at a cost for labor of $0.73 per cubic yard of crushed rock. The cost of labor for lining the tunnel was $5.25 per cubic yard, including quarrying and crushing of rock, or $5.07 per lineal foot, as above. The volume of concrete placed in the lining was 0.9640 cu. yd. per lin. ft. (0.8372 for top and sides and 0.1268 for the invert). As the volume required for a lining 6 in. thick would have been 0.5807 cu. yd. per lineal foot the overbreak was 0.3833 cu. yd. or 66 per cent.

The tunnel was driven largely through black serpentine in which basalt boulders were frequently encountered. In places the formation was basalt and hard shale with seams of serpentine. Occasionally green serpentine was encountered. The tunnel may be considered a dry one, as water caused but little difficulty. A little trouble was caused by natural gas. Powder used for blasting was 40 per cent nitroglycerine, of which the quantity used was nearly 9 lb. per lineal foot, or 3 lb. per cubic yard.

Because of the inaccessibility of the west portal of the tunnel the compressor plant was placed about 1,000 ft. from the east portal and about 2 miles from the west portal. Air was piped to the portals through 3½ in. pipe lines. The plant consisted of three 25 hp. Fairbanks-Morse Y type semi-diesel engines and three 8 by 8 in. Sullivan compressors. A pressure of 100 lb. per square inch at the plant was maintained and about 300 cubic feet per minute of free air was compressed. Legner drills with sets of steel ranging to 8 ft. in length were used for driving the tunnel. Jackhamers were used for trimming.

The work was completed and turned over Jan. 31, 1919.

Water Waste Control by House Inspections With District Metering

Water waste control in city distribution systems is a problem of ever-growing importance. Increased costs of extensions which are necessary if waste is not curtailed have made it important that every water works manager seek to reduce this waste to a minimum. E. D. Case, vice-president, The Pitometer Co., New York City, in a paper read before the recent convention of the Southwestern Water Works Association, states that water waste may be said to come under two general heads: (1)—Underground leakage; and (2)—House waste. While the first item exists to a greater or less extent in all water works system, it is usually smaller by comparison to the second, especially in unmetered plants. The item of house waste may be further divided into three sub-heads:—

(1)—Willful waste; (2)—Leaking services; and (3)—Leaking fixtures.

The most obvious and effective means of controlling waste of this kind is to place meters on all services. Unfortunately, however, local conditions make universal metering impossible in a great number of places.

A system of district metering with house-to-house inspection has been in use for a great many years. Certain drawbacks attendant to the establishment of permanent district meters have been overcome by the development of the pitometer, a portable meter and a practical application of the Pitot tube.

The use of the pitometer has been extended to a number of cities. Successful results have been obtained in Trenton, N. J., and Buffalo, N. Y. In Trenton, the daily consumption had gradually increased from 9,000,000 gal. in 1902 to 21,000,000 gal. in 1913. This was partly due to increase in population and industrial use but in most part was due to the fact that waste conditions were becoming greater as no steps were taken to curtail them. In 1914, when the population supplied was approximately 125,000, the Pitometer system of controlling water waste was installed, with the result that in a year's time the consumption had been reduced to 15,000,000 gal. a day. If nothing had been done to stop the waste, the consumption would have been about 27,000,000 gal. per day, based on the average rate of increase for the 10 preceding years. This means a saving of $4.40 a day in coal alone. In addition, the need of a new reservoir and a new pump was put off indefinitely, with the resulting necessity for larger mains.

For a great many years Buffalo had the distinction of having the highest per capita consumption of any city in the United States. In 1917, just pior to the start of the water waste survey, about 180,000,000 gal. a day were being pumped into the mains, or a per capita of approximately 360 gal. In June, 1917, the Pitometer system of waste control was installed, and the daily consumption has now been reduced to about 120,000,000 gal. a day, or a per capita of 210 gal., although the first inspections have not been extended over the entire city. Of this amount, 100 gal. daily per capita are sold to the industrial consumers, leaving a domestic per capita of about 140 gal. This is still far in excess of the actual need of domestic consumers, but is being reduced day by day, and within the next year will undoubtedly reach a reasonable figure.

For the purpose of the survey, the city was divided into ten sections and each section subdivided into a number of districts. The flow was then measured into each district by the pitometer, and further investigations made by subdividing each district at night, so that the rate of flow between each pair of valves was determined. Wherever this seemed excessively high, inspectors were sent into the blocks to locate and stop leaks. Each inspector was equipped with a blank form, which enables him to report the number, location and cause of all leaks discovered on the services or on the premises of consumers. Notices were left with the property owner, and a duplicate filed in the water works office, which required that the leaks be stopped within a designated number of days, with a penalty of shutting off the service in case repairs were not made. After reinspections had been made to determine that all waste had been stopped, a remeasurement was made of the entire district and the results recorded.

In order to discover the permanency of the reduction in various sections of the city, remeasurements were made of the flow in typical districts after periods of 6, 12 and 18 months had elapsed. In this way it was determined that in some sections of the city the waste had not returned in a sufficient amount to warrant reinspections until a period of 18 months had elapsed. In other sections the investigations proved that in order to control waste, yearly inspections should be made; while in still other sections notably those containing the pocrer class of consumers, with exposed plumbing and anti-freezing toilets, inspections every six months, or even oftener, were necessary in order to control the waste.

Result of First Year's Operation of Point St. Charles Filtration Works, Montreal

During the 12 months ending June 30, 1919—the first year of operation—the Point St. Charles Filtration Plant, Montreal, was requested to furnish an average of 12.8 mil. gal. per day in excess of its capacity.

The average daily consumption for the year was 63.1 mil. gal. per day, of which 50.3 mil. gal. per day was filtered and the rest was row river water mixed with the filtered water and chlorinated, according to an article which recently appeared in The Canadian Engineer.

During July, 1918, which was the first month after operation commenced for which complete data of all laboratory tests are available, with a raw water count of 530, the prefilters showed 87.9 per cent bacterial efficiency, and the final filters, 95.3 per cent. The filtered water was mixed with 16.1 mill. gal. of raw water, and the mixture was chlorinated, the final bacteria count of the water as delivered to the mains showing 93.7 per cent removal.

The bacteria-removal figures vary considerably until the end of September, 1918, at which time the plant appears to have been "tuned up" to an average condition of efficiency.

From October, 1918, to June, 1919, both months inclusive, the final filter bacterial efficiency ranged from a minimum of 96.2 per cent in June, 1919, to a maximum of 99.1 per cent in May, 1919. The bacteria-removal of the combined raw and filtered water after chlorination ranged, in the same period, from a minimum of 98.1 per cent in October, 1918, to a maximum of 99.8 per cent in April, 1919.

The plant has both a shore intake and a mid-stream intake situated about two miles above the Lachine Rapids of the St. Lawrence River. From an entrance gate chamber which receives the supply from both intakes, a concrete conduit, 8.5 ft. in diameter, connected into a 9-ft. concrete conduit, brings the untreated St. Lawrence River water to the filtration pumping station. The purpose of this pumping station is to lift the water to the prefilters, a height of approximately 18 ft., and to furnish water at a higher pressure for washing the prefilters at times of cleaning.

From the prefilters, or rapid filters, which form the first step in the purification process, the water flows by gravity to the final filters, which are quite similar in construction to slow sand filters. Passing through the final filters, the water flows into the filtered water reservoir, and is subsequently chlorinated.

From the filtered water reservoir, the water flows to the filtration pumping station, from which it is pumped to the low level pumping station, where it is forced by high pressure pumps through the distributing mains and to the city's reservoirs.

The pre-filters, located east of and adjoining the pumping station, and supported by groined arches above the roof of the filtered water reservoir, are 16 in number, each having a net filtering area of 1,200 sq. ft., arranged 8 on each side of a central operating gallery. Each pre-filter is divided longitudinally by a central gutter into which empty the 16 lateral reinforced concrete wash water gutters. The strainer and air system is made up of cast iron headers and 2-in. cast iron laterals, with brass strainers spaced at 6-in. centers. The filtering material consists of 15 in. of gravel, graded into four sizes and placed in corresponding layers, and 30 in. of filter sand. The final filters are 16 in number, and are arranged 8 on each side of the operating gallery. The filters are covered by grained arches supported on piers spaced 13-ft. centers. The pier load is carried on foundation blocks independently of the rest of the floor, which is flat and but 5 in. thick. The filters are each 55 by 340 ft., inside measurements, with the short dimension adjoining the gallery to accommodate the use of Blaisdell washing machines for the filter cleaning.

The underdrainage system consists of two half-round 8-in. tile laterals in each bay, which discharge into a central main collector, 2½ ft. in diameter, extending the entire length of the filter below the floor level. The filter material includes 12 in. of graded gravel, placed in four layers, and 27 in. of sand.

Heating throughout the entire works is accomplished by means of electric radiators.

The cost of the plant is given in the following table:

FILTRATION CONTRACTS.

	Cost.
Pumping machinery, blower and cranes, British Electric Plant Co.	$ 40.250.00
Final filters and appurtenances, F. H. McGuigan, transferred to Norman M. McLeod	674,436.20
Prefilters and filtered water reservoir, F. H. McGuigan, transferred to Norman M. McLeod	498,782.30
Pumping station, wash-water tower and buildings, F. J. Jago Co.	160,076.00
Interior painting, Charles Larin	1,815.42
Exterior electrical conduit system, G. M. Gest	6,069.80
Underground electrical cables and appurtenances, Northern Electric Co., Ltd.	12,627.04
Transformer building, city of Montreal	6,000.00
Total cost	$1,400,056.76

The filtration works were constructed under the general supervision of Paul E. Mercier, engineer of public works, and T. W. Lesage, engineer-superintendent of water works. Frederick E. Field is the assistant superintendent of water works; A. B. Reid, electrical and mechanical engineer; Allan Kilpatrick, chief filter operator; and J. H. Harrington, chief chemist.

For Appointment of Engineer as Member of Interstate Commerce Commission

Engineering Council through its chairman, J. Parke Channing, has sent the following letter to President Wilson, pointing out the desirability of appointing an engineer to fill the vacancy on the Interstate Commerce Commission:

> The transportation systems of our country are largely the creators of its professional engineers. This statement can be made without disparagement to the statesmen, the financiers, the manufacturers, the lawyers, the educators, the mechanics, the laborers and many others, who, with the engineers, have contributed to the development of transportation. Through all stages of preliminary exploration, final survey, construction, upkeep and operation, in financial management, and in adjustment of the relations of transportation to the public, the genius and knowledge of the engineer are essential. Not only in technical physical matters, but also in determinations of policy, his contributions have supplemented and must ever supplement those of other men. These declarations hold good for all the carriers of commerce, by rail, by highway, by water, by pipe-line, by wire, or by air. Hence, it follows that the body established by Government to regulate the commerce, the carriers and the ways of communication, embracing so many engineering features, should number among its nine members, men of engineering training and experience.
>
> Engineering Council, being aware of a vacancy on the Interstate Commerce Commission, begs leave to request the Chief Executive that in filling this vacancy, he give earnest thought to the selection of a man who, to his other qualifications, add the training and experience of an engineer familiar with transportation problems.
>
> Engineer members wisely chosen would bring to the investigations and deliberations of the Interstate Commerce Commission not only technical knowledge of great value, but also experience in executive duties, a judicial attitude gained through the direction of work under contracts, minds of analytical habit, familiarity with costs of construction and operation, experience in dealing with employes of many vocations, and integrity of thought cultivated by that inescapable obedience to the laws of Nature involved in the practice of this profession. The engineer's training fits him for that mode of thinking which is indispensable to impartiality of judgment. One important function of the commission is valuation of public utilities and other is the determination of relationships and responsibilities of the management of such utilities to the public. No other body of men has given so extensive and so scientific consideration to these matters as have members of the engineering profession.
>
> Council's purpose is not to further the interests of any individual or group, but solely to serve the Nation by strengthening one of its most important regulatory bodies. Upon the wisdom, intelligence and courage of this commission depends in large measure the commercial welfare of the country. It is believed that the engineering profession can and should contribute to the country's well being through the channel of membership in the Interstate Commerce Commisison.

Yields and Returns From Irrigated Land

Interesting figures on the production from irrigated land in the Rio Grande Project (New Mexico-Texas) of the U. S. Reclamation Service are given in the August Reclamation Record. The following table, showing the yields per acre and the sales, has been compiled from the books of a vegetable raiser in the Misillo Valley, who has kept records of his crops systematically and accurately for 14 years:

	Acres.	Total. Lb.	Av. per acre. Lb.	Gross sales net cash to grower.	Sales per acre.
Asparagus	11	30,378	2,761	$2,820	$256
Spinach	11.7	132,337	11,319	5,459	458
Tomatoes	3	53,347	17,782	1,678	560
Cantaloupes	8.27	2,133*	258*	4,269	407
Cucumbers	2.45	2,927†	1,195†	913	317
Cabbage**	1.79	19,332	10,800	704	449
Sweet peppers	1.25	11,336	9,607	659	527
Egg plants	.50	394†	788†	268	536
Green chili	1.18	9,338	7,913	996	844
Okra	.66	2,937	4,450	214	325
Squash	.20	1,868	9,340	144	719

*3-tier standard crates. †Dozen. **Small early heads.

The grower from whom the data were obtained also figures out what has been the actual cost of producing each crop ready to put on the market. The figures include cost of growing, gathering, packing and container. The cost in most cases would be lower if it were not for the extra expense incurred by forcing crops to get them early or to mature at a certain time of the season when the market is good. In some instances the box, barrel or container is 25 or 35 per cent of the cost of production.

AVERAGE COST PER UNIT.

24-lb. box of asparagus	$0.83
100-lb. barrel iced spinach	1.63
20-lb. 4-basket crate tomatoes	.35
Crate of 45 cantaloupes	.62
14-lb. basket snap beans	.38
11-lb. basket peas	.42
100 lb. sacked sweet potatoes	.48
Box 4 dozen bunches of radishes	.28
Crate of 3 dozen cucumbers	.33
50-lb. crate small early cabbage	.71
10-lb. crate sweet peppers	.19
Crate 1 dozen egg plants	.27
10-lb. basket green chili	.29
100 lb. garlic, sacked	2.82
12-lb. 4-basket crate of okra	.47
25-lb. crate of squash	.42

Sewer Construction at Detroit, Mich.

The city of Detroit, Mich., now has about $9,000,000 worth of construction under way, most of this being sewer work. Additional contracts amounting to possibly $5,000,000 will be let as soon as funds are available. The following tabulation gives a few details of some of the sewer contracts now being carried out:

Location.	Type sewer.	Constrection method.	Length. ft.	Contract price.	Av. No. workmen.	Av. wages labor per hour.	Contractor.
Lonyo Road	Concrete, 2-box each, 14x14½ ft., and 3-ft. concrete cylinder.	Open cut	8,300	$1,430,000	65	$0.50 to $0.95	Walbridge & Aldinger, Chicago.
Weatherby	Concrete, horse shoe shape.	Open cut	10,500	990,478	24	.55 to 1.25	Nash Bros., Chicago.
Dexter	2-ring brick, 5½-ft. cylinder.	Tunnel	7,956	136,539	21	.55 to .90	Wm. Porath, Detroit.
Linwood	3-ring brick and concrete, 7-ft. to 9-ft. cylinders.	Tunnel*	11,929	379,450	90†	...	Jaynes & Affeld, Detroit
Lynch Road, Sec. 1	4-ring brick to smaller	Open cut and tunnel	**	389,918	36	.55 to 1.25††	Geo. R. Cook, Detroit.
Lynch Road Sec. 2	4-ring brick to smaller	Open cut and tunnel	**	260,200	52	.60 to 1.10*†	Carpenter Const. Co., Detroit.
Hart Ave	20-in. tile	Tunnel and open cut	2,859	17,252	38	.60 to 1.00	J. M. Affeld, Detroit.
Erwin	4¾-ft. and 5-ft. concrete cylinders.		2,860	48,520	..	...	R. D. Baker, Detroit.
Alter Road	5½-ft. brick and concrete cylinders.	Tunnel	1,820	77,010	17	.60 to .90	J. M. Affeld, Detroit.

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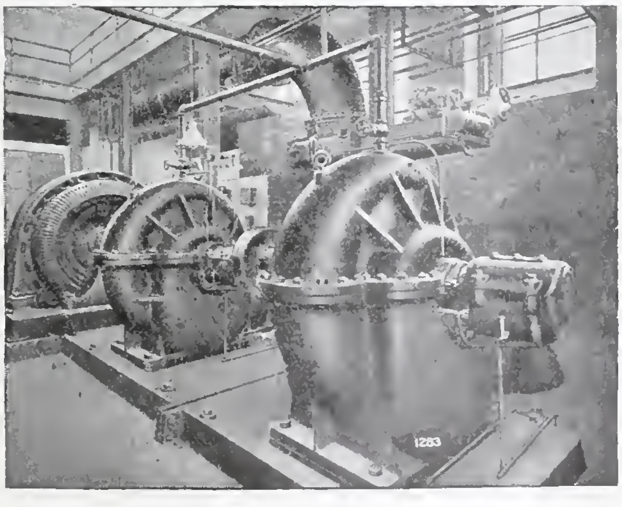
*With tunnelling machine. †Work in three sections—Sec. 1, 45 men at 65 ct. to $1.25 per hour; Sec. 2, 47 men at 55 ct. to $1.25; Sec. 3, 8 men at 65 ct. to 95 ct. **Total for two sections of Lynch Road sewer, 25,220 ft. ††Open cut work. *†Tunnel work.

POWER AND PUMPING SECTION

This section of the Waterworks and Hydraulic Monthly issue of Engineering and Contracting is devoted to the selection of power and pumping equipment and the economic management of its operation.

Test Shows Over 82 Per Cent Efficiency of Motor-Driven Centrifugal Pump

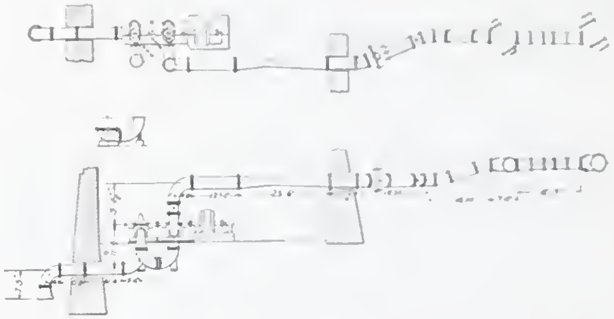
In a paper read before the Minnesota Section of the American Water Works Association, Mr. F. W. Capellen, City Engineer of Minneapolis, stated that in May, 1911, the city entered into a 10-year contract with the Minneapolis General Electric Co., now the Northern States Power Co., by which that company agreed to furnish current at 2,200 volts to operate two or more 20,000,000 gal. pumps against a dynamic head of 240 ft., based upon a pumping set of 72 per cent overall efficiency, at a price of $4.00 per million gallons pumped, the understanding being that no current would be used between 4:15 p. m. and 6:30 p. m. on week days during the months of November, December, January and February. In November 1916, a similar 10-year contract was made with the same company for the operation of a 30,000,000 gal. pump against the same head, and with the same pump efficiency, to be charged for at the same rate, with the provision that at a different dynamic head or efficiency, the price per million gallons should be adjusted accordingly. It was also specified that the motor to be used by the city should be capable of starting the pump when primed and with the check or gate valve in the discharge closed, and of bringing the pump to full speed without drawing more than 150 per cent of full load current from the source of supply. In 1910 and 1911, two 20,000,000 gal. pumps were installed, and in 1918, a 30,000,000 gal. unit.



30,000,000-gal. De Laval Motor Driven Centrifugal Pumping Unit.

The latter unit consists of a General Electric, 1,800-hp., three-phase, slip-ring, induction motor, directly connected to two De Laval, 24-in., single-stage pumps, mounted upon the same base plate and connected in series. The unit was specified to deliver 30,000,000 gal. per 24 hours against a total dynamic head of 250 ft. It was supplied by the Minneapolis Electric Equipment Co., and is installed at Pumping Station No. 4 in Northeast Minneapolis.

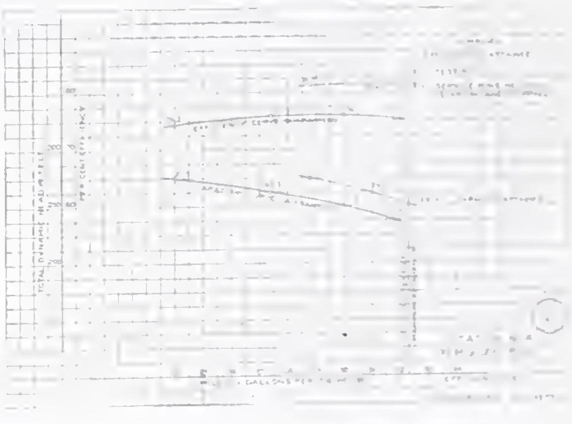
The official acceptance test was made on May 28 and 29, 1918. The discharge was measured by means of a Venturi meter, the capacity being calculated from manometer readings, while the discharge head was measured by two sets of calibrated gauges and the suction lift by means of a mercury column. The power supplied was measured by three sets of watt-hour meters, calibrated by means of a portable set of standard instruments read during the official test under the conditions of current, voltage and power factor obtaining. The portable set included two single-phase watt meters, one polyphase watt-meter, one volt meter, four ammeters, and portable current and potential transformers. All instruments were checked and calibrated in the presence of witnesses. The test lasted 28 hours. The results were as follows:



Location of Pump and Force Mains.

Total pumpage in 28 hours, gal.	7,71[illegible]
Rate per 24 hr., gal.	[illegible]2,321,[illegible]
Discharge head, average, ft.	[illegible].13
Suction lift, average, ft.	16.43
Total dynamic head, average, ft.	251.7[illegible]
Kilowatt hours used	[illegible]6,367.2
Combined efficiency of motor and pump	82.1%
Average line voltage	2,40[illegible]
Power factor	[illegible]0.0%
Motor efficiency under test conditions	95.[illegible]%
Slip of induction motor	1.1%
Temperature rise	[illegible]5.5 C.
Starting current, percentage of full load current	113.[illegible]%

The contract of the city with the Minneapolis Electric Equipment Co. provided a bonus of $500 for each one per cent of efficiency exceeding 76 per cent when pumping 30,000,000 gal. per day against a total dynamic head of 250 ft. The maximum bonus was limited to $2,400. A penalty of $500 was provided for each 1 per cent by which the efficiency might fall below 76 per cent and the pump was not to be accepted if the overall efficiency fell below 72 per cent. As the accompanying chart shows, 76 per cent efficiency was exceeded at all loads tested, and the average combined efficiency, including the regular starting and other conditions incidental to a varying load in regular service, should not be less than 82.1 per cent by more than 1 per cent. The overall efficiency of 82.1 per cent divided by the motor efficiency of [illegible] per cent gives a pump efficiency of 85.97 per cent.



Capacity and Efficiency Curves Showing Results of Tests.

The following operating data were obtained during the first three months after the test:

Gallons pumped	2,797,490,000
Power cost per million gal	$3.63
Labor and supplies per million gal	$2.27
Total cost per million gal	$5.95
Head, ft.	253.06
Overall efficiency, per cent	81.4

Similar records for the first nine months subsequent to the test are as follows:

Gallons pumped	6,526,350,000
Power cost per million gal	$3.72
Labor and supplies per million gal	$1.77
Total cost per million gal	$5.49
Head, ft.	255.80
Efficiency, per cent	82.48

The low prices which the city realizes on its power contracts with the electric company are of course explainable in that the contracts were made some time ago and for a long term.

How to Increase Boiler-Room Efficiency*

By D. S. JACOBUS,

Advisory Engineer, Babcock & Wilcox Co.

More is often to be lost or gained in the operation of the boiler room than in any other part of a power plant. To secure efficiency and capacity we all know that the following features must be watched after: The surfaces of the boiler must be clean inside and out and the gas passages and flues must be free and unrestricted from the deposit of soot or ashes; the baffles and settings must be reasonably free from leakage; the fuel must be properly fired.

To secure the best efficiency, the fuel or any combustible elements distilled from the fuel must be completely burned within the furnace chamber. Again, the combustion must be such that the gases that pass from the furnace are uniform in composition; that is, some of the gases must not contain a considerable amount of excess air and others possibly a deficiency of air, thus leading to what is termed a laneing action.

If the gases are burned entirely within the furnace chamber, the entire surface of the boiler is effective in absorbing heat. If there is secondary combustion between the boiler tubes, which may occur to a considerable extent if there is a laneing action in the gases and may possibly extend entirely through the setting, all of the boiler surface is not effective after combustion is complete, with the result that there is an increase in the temperature of the flue gases over what it would be should the gases be burned within the furnace, and a corresponding loss of efficiency. Again, in some instances there is a loss through combustible elements, such as carbon monoxide, passing off in the flue gases. Another loss that is experienced in coal burning is through the unconsumed fuel in the ashes, often due to poor operation.

Test Results and Operating Results.—It is a mistake not to provide proper instruments to guide the firemen. A general impression prevails that test results are one thing and operating results another, and that the operating results necessarily fall considerably below the test results. Operating results do as a rule fall considerably below the test results, but there is no reason why this should be so in the great majority of cases.

It is often assumed that the average flue-gas analysis combined with the percentage of carbon in the ash is a measure of the efficiency of a furnace, and that if these features are known the boiler man should be able to guarantee the boiler efficiency. Such is not the case, as a great deal depends on whether all of the combustion is or is not completed within the furnace chamber. If there is delayed combustion between the tubes of the boiler, it will have an influence on the flue-gas temperature and efficiency, and it can readily be appreciated that if two plants are operating with the same average flue-gas analysis and percentage of carbon in the ash, and in one of the plants there is secondary combustion between the tubes and in the other there is not, the plant where all of the combustion is completed in the furnace will have the highest efficiency.

Percentage of Carbon Dioxide as Indication of Boiler Efficiency.—Often great stress is laid on carrying a high percentage of CO_2 irrespective of the other operating conditions, and in certain instances the firemen are paid bonuses based on the percentage of CO_2. If all the other conditions of operation are watched after, this system will give good results; but if the carrying of a high percentage of CO_2 is made the sole aim of the firemen, there may be wastes in other directions that will counterbalance any gain through minimizing the amount of excess air.

Where a high percentage of CO_2 is carried, it is often found that CO will be present. In some installations it is impossible to carry more than a certain percentage, say 13 per cent, of CO_2 before having a material amount of CO. An analysis with coal firing which indicates 13 per cent of CO_2, and no CO is more favorable from a heat-loss standpoint than one that gives 15 per cent of CO_2 and ½ per cent of CO. As the carrying of a high percentage of CO_2 is apt to lead to secondary combustion between the boiler tubes, thereby involving an additional loss through increasing the temperature of the flue gases, it can readily be seen that it is often a mistake to aim for too high a percentage of CO_2. How high a percentage should be aimed for depends upon the form of furnace and the furnace volume. Ordinarily, with coal it does not pay to exceed about 13½ per cent.

The Hempel type apparatus, where the gases are shaken up with the solutions, is, as a rule, more reliable in indicating the amount of CO than the Orsat, and in accurate work it is well to check the Orsat apparatus against the Hempel.

Loss of Efficiency Due to Impure Feed Water.—The use of impure feed water is entirely too prevalent. This naturally leads to a loss in efficiency through incrusting the inner part of the heating surface and through making it necessary to blow down the boilers an undue amount. There is an added loss through having to cut out the boilers a large part of the time for cleaning and for replacing leaky tubes. Greater attention is now being given to securing clean feed water, especially in the larger plants. In many instances it pays to install evaporating apparatus for supplying the makeup water. Naturally, this can be done only where surface condensers are used, but where it can be done good results are bound to follow.

A considerable loss in plant efficiency in coal firing often comes through the carrying of banked fires. There is a corresponding loss in burning other fuels, and the operation of a given plant may cause this element to greatly affect the results secured. As an instance, in one particular case where I was active in securing the best results, the economy of an oil-burning plant was raised over 25 per cent simply through operation and by going over the plant to eliminate heat losses through drips, etc.

Securing Efficiency in Oil Burning Plants.—In oil-burning plants a mistake is often made in keeping the steam pressure as steady as possible by changing the firing conditions one way and the other to such an extent that it is impossible to maintain the best furnace efficiency. The best results are secured by feeding the oil to the burners at a reasonably uniform rate, varying the oil pressure one way and the other slowly to meet the demands of the power, even though this may result in a less steady steam line than would be secured through jumping the oil pressure one way and the other to maintain a practically constant steam pressure. A recording pressure gage placed on the oil line where the steam pressure is maintained at a constant figure will often give illuminating results in indicating a broad band with the oil pressure varying 200 or 300 per cent one way and the other, whereas for best operation the oil pressure will be represented by a reasonably steady line which will follow in a general way the power requirements. A good guide for efficient operation in running with oil fuel is the amount of superheat obtained, which should be about uniform in all the boilers. If the superheat in a boiler becomes high, it is due either to running the boiler harder than the others or to excess air, either of which conditions should be corrected to obtain the best results.

Another good guide in oil burning is to observe the appearance of the gases as they pass through the setting. If the gases are clear, it indicates excess air, and if too smoky, an insufficient air supply. For the best results there should be a slight haze throughout the gases. The appearance of the gases leaving the stack is also a good guide, as too clear a stack indicates excess air, whereas a smoking stack shows insufficient air in one or more of the boilers, the best conditions being indicated by a slight haze.

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*Abstract of a paper presented before the American Boiler Manufacturers' Association, Buffalo, N. Y.

Bonuses for Operating Crews.—It is feasible to set a figure for efficiency higher than that which would ordinarily be secured and to pay the operating crew a certain bonus based on the increase in efficiency above this figure. In this connection, Edward N. Trump has said the following:

If you give a bonus to the firemen, you will be sure to have some improvement in efficiency. I have found at least 10 per cent saving by paying bonuses to the firemen, sometimes by working one shift against the other. Competition encourages them to work harder, to increase the saving.

Mr. Trump has secured record efficiencies in the plants of his company. With boilers of about 300 HP., fitted with economizers, run at from 100 to 120 per cent of rating, he has secured plant sufficiencies, measured by the monthly operation, of 85 per cent. In his boiler plants with very large units he has obtained a corresponding efficiency of 88 per cent. The load on the boilers in Mr. Trump's plants is nearly uniform and does not vary to the extent that it does in the average electrical-power generating station.

For a long time there were many instances where the use of the older type of waste-heat boilers would not lead to a good return on the investment. Since developing our modern type where the boilers have a considerably higher draft resistance than in the older type and where this draft resistance is overcome through the use of an induced-draft fan, we have installed over 100,000 HP. of such boilers in connection with openhearth furnaces alone, and the steam generated by these boilers represents a saving in the neighborhood of 1,000,000 tons of coal per year. This is only one of the fields where waste-heat boilers may be applied to advantage, and it shows the magnitude of the savings that can be effected.

Design of Furnace and Stoker.—Furnace design cannot be divorced from stoker design when the best obtainable results are aimed for. After designing the stoker, the next feature bearing on economy is the disposition of the surface of the boiler. With a given boiler arrangement, tube spacing, etc., it usually follows that to secure a high heat transfer the draft resistance will be greater than with the same amount of surface arranged and provided with baffles that will give a lower rate of heat transfer. If the arrangement of heating surface and baffles is such as to lead to too high a draft resistance, the capacity developed by the boiler with a given draft may be lower than desired. If the arrangement is such as to give a low draft resistance, the efficiency may be less than it should be. In providing a proper design, one of these features must be balanced against the other and an arrangement provided which will give the best all-round results.

The addition of an economizer will increase the economy, say, 5 to 10 per cent. Now that the price of fuel is increasing everywhere, a greater number of economizers are being installed.

For large plants the efficiency obtainable with a modern steam-boiler and steam-turbine installation is greater than could be secured through gasifying the coal in producers and using the gas in gas engines. A large steam-turbine plant of the best modern design will generate a kilowatt-hour with a heat consumption based on the heat in the fuel of 17,000 b.t.u. per kw.-hr. This as a round figure for plants of the best modern construction with a load factor of, say, 60 per cent and steam pressures of from 250 to 300 lb.

By increasing the steam pressure and raising the superheat, the figure can no doubt be reduced to the neighborhood of 15,000 b.t.u. per kilowatt-hour. There is no likelihood of the gas engine displacing the steam turbine for large power generating station work for some time to come.

Water Waste Surveys Cuts Consumption 50 Per Cent.—As the result of a water waste survey last year the average daily consumption of Newark, O., a city of 30,000 population, was reduced from 3,932,000 gal. to 1,845,000 gal. Of the 2,087,000 gal. decrease, 552,000 gal. was from leaks located and stopped, and 895,000 gal. was from the stoppage of illegal use by one consumer. This leaves 640,000 gal. decrease unaccounted for. Of this latter total 140,000 gal. is assumed to come from the stoppage of two leaks subsequently discovered by the city. The remainder is thought to represent the consumption of another large consumer who discontinued his illegal practice after the investigation was started.

Pulverized Coal Plant of Puget Sound Traction, Light and Power Co.

With the rapid increase in the price of coal and [illegible] since the beginning of the world war, boiler plant operation became more and more costly. Shortly after the United States entered the war, fuel oil and coal, along with other war essentials, were placed under close Government control. To overcome transportation difficulties each section of the country was requested to become self-supporting wherever possible, and for the state of Washington this meant, among other things, the use of local coal instead of the imported fuel oil in the operation of all steam plants.

The Puget Sound Traction, Light & Power Co. of Seattle, Wash., includes among its public utilities a steam heat plant, having in service four 300-HP. boilers with superheaters of 100°—120° superheat, three 400-HP. boilers, one 500-HP. boiler and two 600-HP. boilers, one of which was installed during 1918. The boilers are Babcock & Wilcox vertical header type water tube boilers, supplying steam at 125 lb. pressure. The superheaters installed in the 300-HP. boiler only are also of Babcock & Wilcox manufacture.

This plant was being operated with fuel oil, so in the early summer of 1917 a careful study was made in the use of coal as fuel, to decide on the most economical design of a coal burning plant. Pulverized coal had been tried out at the plant and very satisfactory results were obtained, one of the 300-HP. boilers having been arranged for the series of tests which were made during the early months of 1917. The results of these tests, together with the fact that an enormous culm dump of over 225,000 tons at the Renton Mine, a short distance from Seattle, was available as fuel, led to the decision to use pulverized coal as a fuel for the steam plant. As a consequence a pulverized coal plant having several interesting features was put in. The following description of this installation is taken from the August Stone & Webster Journal.

The original plans called for pulverized coal for one-half the plant only, but after a careful study of first costs it was decided to equip the entire plant for the use of pulverized coal. Another important feature in using pulverized coal is the availability of the present oil burning equipment when fuel oil is again restored to its former basis. This permits an interchange of fuel, in case of emergency, of either short or long duration, produced by breakdowns or other unforeseen causes.

The Culm.—The culm dump consists of the washings from the Renton Mine, where a Washington lignite coal is mined having a calorific value of approximately 9,000 B.T.U. with 18 per cent moisture and 16 per cent ash. The culm as received has a calorific value of approximately 7,300 B.T.U., adherent plus inherent moisture 25 per cent, volatile matter 28 per cent, fixed carbon 26 per cent, ash 20 per cent. This culm costs $0.75 per ton at the mine, 25 ct. per ton loading charges and 60 ct. per ton freight charges, or $1.85 per ton f.o.b. raw coal bunkers.

Construction.—The construction of the plant for the utilization of pulverized coal may be described under the following heads:

(1) Handling raw coal—Conveying coal from storage bunkers on east side of Western Ave. to raw crushed coal bunkers.

(2) Drying—Conveying coal from raw crushed coal bunkers through the dryers to dry coal bunkers.

(3) Pulverizing—Conveying coal from dry coal bunkers through the pulverizing mills to the pulverized coal bunkers.

(4) Burning—Conveying coal from pulverized coal bunkers to furnace.

(5) Handling the ashes.

(6) Miscellaneous construction.

Raw Coal Bunkers.—The raw coal bunkers are of [illegible] wood construction, three in number, having a total capacity of 725 tons. The bunkers are raised to such an elevation that the coal from them can be conveyed to the plant through a tunnel which is located 6 ft. below the street grade. The bunkers are served by a standard gage double track, coal being delivered in hopper bottom dump cars of 30 tons capacity, handled by an electric motor switching engine. Each bunker is 24 ft. x 24 ft. at the top for a distance of 1[illegible] ft.

downward, at which point all sides slope to the center of an angle of approximately 40° with the vertical. The culm contains an excess of ash and refuse, which greatly retards the sliding action. To aid this action it was found necessary to line all the bunkers with No. 20 gage galvanized iron.

Raw Coal Belt Conveyors.—The raw coal is fed through 32-in. x 24-in. double rack and pinion coal gates to a 20-in. feeder belt. To properly feed the culm it is necessary to open the gates wide. To control the feed an auxiliary hopper has been built directly under the gate opening, with a vertical slide which can be raised or lowered to regulate the coal on the belt. This belt travels at the rate of 265 F.P.M. This belt conveys the coal to a single roll type crusher, built by Mead-Morrison Mfg. Co., which crushes the coal to ½-in. size. A by-pass chute is installed in connection with the crusher so that the smaller size coal can be fed directly onto another conveyor belt. A 10-HP. motor drives the feeder belt and a 30-HP. motor drives the crusher.

The crusher plt, being lower than the ground water level, is provided with a sump for drainage purposes.

The conveyor belt from the crusher passes through the tunnel under the street grade and is a combination incline horizontal belt 20-in. in width. It has a speed of 300 F.P.M. and is driven by a 15-HP. motor.

Raw Coal Elevator.—The elevator consists of a double strand fixed continuous bucket conveyor traveling in a No. 16 gage steel casing, with a speed of 150 F.P.M. The coal is carried up a distance of 75 ft. in this elevator, where it is discharged onto a double strand chain steel flight conveyor.

Raw Coal Flight Conveyor.—The flight conveyor distributes the coal over the raw crushed coal bin through four rack and pinion slide gates in the bottom of conveyor trough, traveling at the rate of 100 F.P.M.

All the coal handling equipment from the storage bunkers to the raw crushed coal bunkers has a capacity of 75 tons per hour, and with buckwheat coal, 90 tons have been handled.

Crushed Coal Bunker.—The crushed coal bunker has a capacity of 325 tons, is constructed of reinforced concrete with a top cross-section of 18 ft. 6 in. x 36 ft., branching into two hoppers, with a 10-in. x 5-ft. discharge opening in the bottom of each.

Dryer Feeders.—To convey the coal from the crushed coal bunker to the two dryers, two 30-in. apron feeders are provided—one for each opening in the crushed coal bunker; each feeder is provided with a vertical sliding rack and pinion gate to regulate the flow of coal. Both feeders discharge into a common chute, in which is arranged a flopper gate and steel plate diaphragm which can be so set that either feeder may discharge coal into either dryer or both dryers. Each feeder has a capacity of 25 tons per hour, and a speed of 20 F.P.M.

A 6-in. screw conveyor with a steel plate hopper handles the drippings from the return side of each feeder and discharges these drippings into the feeder discharge spout. Both feeders and screw conveyors and their drives are supported from the under side of the raw crushed coal bunkers. Both feeders and their screw conveyors are driven by one 7½-HP. motor.

The feeder discharge chute branches into two 10-in. pipe sections which feed into the two dryers.

Owing to the high temperatures encountered at the lower end of the pipes, a special paddle arrangement was devised to clear the pipe, which eliminated the use of a bearing in the high temperature. A series of paddles 8 in. long were welded about the circumference of an extra heavy 1½-in. pipe. They are spaced at an angle of 90° from each other, following in consecutive order and are given ½-in. lag. This pipe is mounted on a 1 7/16-in. shaft, which is held stationary in the feed pipe by means of brackets. The bracket at the lower end is fastened directly to the bottom of the feed pipe which projects into the dryer a distance of 18 in. The upper end of the feed pipe is a lateral, the side opening of which connects directly with the main discharge chute. The paddle extends up through the straight section of the lateral, the upper bracket holding the shaft being supported to the framework outside the pipe. The cover for the upper end of the feed pipe is a special casting which bolts to the flanged end of the pipe and supports the bearings for the drive shaft propelling the paddle. Each paddle is driven by a 1-HP. motor, belt connected, speed 60—70 R.P.M.

Dryers.—The dryers are of the indirect fired rotary type, manufactured by the Fuller Engineering Co.—one 5 ft. diameter by 52 ft. long, the other 6 ft. diameter by 52 ft. long. The firebox is built to the side of the dryer, setting being connected to the same through an arched opening.

Vertical baffles control the direction of the heat, forcing it to cross and recross the dryer. Beyond the last baffle the heat passes through the breeching to a hood which connects with the lower end of the dryer. The temperature of the gases at this point is reduced to about 500° F.

An induced draft is produced for the dryers by two Sirocco fans, the fan for the larger dryer having a capacity of 25,000 cu. ft. per minute and the one for the smaller dryer having a capacity of 16,000 cu. ft. per minute, each driven by a single stage Terry steam turbine. The fan is directly connected to the feed end of the dryer, which is enclosed in a concrete setting separate from the furnace, the latter beginning 10 ft. from the upper end of the dryer. By this arrangement the heated gases from the breeching are drawn through the dryer over the coal, thus greatly aiding in the drying process. The temperature of the gases passing through the fan is about 270° F.

Dust Recovery.—As first installed, all but the finest dust was collected in the cyclone and carried downward through spouts into 6-in. screw conveyors, one for each cyclone. These conveyors fed into another 6-in. screw conveyor which carried the discharge into the dryer feed pipes. This arrangement proved unsuccessful, as the dry dust, mixing with the wet coal in the feed pipe, caked on the sides of the pipe and continually choked the pipe. Then again, this dust being carried to the feed end of the dryer would to a large extent be carried up the air duct again and thus travel in a complete circuit. To overcome this disadvantage the discharge screw conveyor was relocated and extended so as to discharge into the dry coal elevator, described below. After several trials here it was found to be too small to handle the amount and the kind of material here encountered. With the finer dust the 6-in. screw conveyor does not appear to operate successfully when fed to capacity, as the screw has a tendency to pack. The 6-in. screw conveyors were taken out and one 12-in. screw conveyor, enclosed in a cast iron pipe, was substituted. The bottom of the cyclones was directly connected to the upper end of the conveyor by 10-in. pipes.

Dryer Capacities.—The smaller dryer's capacity is 7 tons per hour, and the larger dryer will handle 10 tons per hour. The moisture content is reduced from approximately 16 per cent to 2.25 per cent with a temperature of 220° to 240° for the discharged coal. These results were obtained with Newcastle buckwheat; the figures will be reduced somewhat with culm.

Dry Coal Elevator.—The coal from the dryers discharges into spouts which, in turn, discharge into the dry coal elevator. On the lower side of these sloping spouts are attached horse-shoe magnetic separators, one for each spout, which retain all iron scrap, such as spikes, bolts, nuts, nails, etc. These magnets are hinged in place and are easily cleaned at regular intervals. The dry coal elevator consists of a single strand fixed bucket type of conveyor in a No. 14 gage steel elevator casing.

From the dry coal elevator the coal is discharged centrifugally into a spout leading to a 12-in. screw conveyor over the dry coal bins. The screw conveyor distributes the coal in the bins through eight steel extension spouts. It is driven by a 5-HP. motor.

Dry Coal Bunkers.—The dry coal bin is of reinforced concrete construction, having a capacity of 160 tons. Access is had to the bin through three cast iron manholes.

As some of the warm air currents will pass up through the supply spout to the elevator, a small vent is installed at the top of the dry coal elevator. In addition to this, a pipe connection is made between the elevator casing about 12 ft. from the bottom and the larger dryer hood to release any gases that may collect in the elevator shaft and also to maintain a continuous circulation of air in the elevator by the aid of the induced draft fan connected to the dryer.

The dry coal bin is subdivided into four hoppers from the bottom of which coal is fed directly to the four pulverizing mills through 12-in. diameter hinged steel spouts. The flow of the coal is regulated at the bottom of the hoppers by means of duplex bin gates.

Pulverizing Mills.—The plant is equipped with three 42-in. Fuller-Lehigh fan discharge type pulverizers and one Raymond impact pulverizing mill, with one 42-in. Fuller-Lehigh mill as a spare.

The Fuller mills each have a capacity of 3½ tons per hour with a resulting pulverized product, 80—85 per cent of which passes a 200-mesh screen, and 95—98 per cent passes a 100-mesh screen. The Raymond has a capacity of 5½ tons per hour with a resulting product, 70—75 per cent of which passes a 200-mesh screen, and 93—97 per cent passes a 100-mesh screen.

In addition to the feed regulation at the bottom of the dry coal bin, the feed hopper of the mill is provided with a slide which can be raised or lowered to regulate the amount of material entering the feeder trough containing a feed screw. This screw conveyor feeds the coal into the mill; it is driven direct from the mill shaft by means of a belt passing over a pair of three-step cone pulleys. This arrangement provides a range of three speeds for the screw feed. Each Fuller mill and the Raymond mill are driven by a 75-HP. motor.

Screw Conveyor—Fuller Mills to Pulverized Coal Elevator—The pulverized coal from the Fuller mills discharges through spouts into a 12-in. screw conveyor, which has a vent box running the full length of the trough. This vent box has a graduated sectional area of from 1½ sq. ft. at first mill to 4 sq. ft. at last mill.

No cyclones or dust collectors are used in connection with the Fuller mill, but the excess air from the mills is carried direct to the furnace through the aid of the 8,000 cu. ft. per minute induced draft fan mentioned above. The fan is driven by a 5-HP. motor. This air, carrying considerable coal dust in suspension, is fed directly to the furnace through auxiliary supply pipes.

To regulate the suction in the vent box an opening 10 in. x 16 in. was cut into the vent pipe just above its connection with the vent box. To regulate the admission of free air to the pipe a vertical sliding door is installed. By increasing the free air intake opening, suction at the discharge end of the mills is decreased and vice versa.

Pulverized Coal Elevator.—The pulverized coal elevator operates in a reinforced concrete housing divided into two compartments, keeping the loaded and empty buckets entively separate from each other. One-half inch clearance was allowed in all parts of the shaft, thus overcoming the possibility of dust lying dormant in any part of the elevator. This type of elevator also insures a dustproof casing. Coal enters the pulverized coal elevator from the 12-in. screw conveyor through a spout. The uptake for this elevator is of a special design and is placed at the top of the elevator. The sprocket at the bottom is stationary, giving the buckets a very small clearance at the bottom of the shaft, which prevents coal dust from accumulating there. This elevator is operated by a 10-HP. motor and discharges into a 12-in. screw conveyor.

Raymond Mill Equipment.—In the Raymond mill the coal is pulverized by impact, an upward current of air from an exhaust fan having sufficient carrying power to take with it the finest particles, leaving the coarser until they are pulverized to the necessary fineness. The discharge from the mill leads to a cyclone separator from which the pulverized coal is discharged into the 12-in. screw conveyor above mentioned. The air discharge from the cyclone separator leads back to the mill, thus completing the circulation. The velocity of the air at the intake end of the cyclone is greater than the velocity at the outlet, hence back pressure results in the mill. To overcome this back pressure an air duct is connected to the return discharge line, through which air is drawn by use of an induced draft fan. This air current carrying fine dust in suspension is fed to one of the boilers through an auxiliary feed line. A 30-HP. motor drives the large exhaust fan from the Raymond mill and a 3-HP. motor drives the fan on the pressure relief line.

Screw Conveyors—Pulverized Coal Elevator to Pulverized Coal Bunkers.—The 12-in. screw conveyor leading from the pulverized coal elevator is centrally located with respect to the boilers. It is directly connected to four 12-in. screw conveyors which operate at right angles to the supply conveyor. These four conveyors lead to the various bins above the boilers, through dust-proof spouts. The feed is regulated by ordinary slide gates in the bottom of the conveyor trough. Each screw conveyor is driven by a 5-HP. motor.

In addition, the supply conveyor is connected to the storage bins supplying the two dryers, through spouts.

Pulverized Coal Bunkers.—The pulverized coal storage bins for the dryer furnaces are constructed of structural steel and have a capacity sufficient for eight hours' steady operation. Of the bins supplying the boilers, eight are of reinforced concrete and two of structural steel. Each has a capacity of approximately 15 tons, sufficient for from 9 to 15 hours' operation, depending on the size of the boiler. These bins are all of dust-proof construction, as is all the coal handling equipment beginning with the dryers and ending with the burners. The bins are so constructed that no pockets will form and that there is very slight possibility of arch action. This allows a free flow at all times of pulverized coal into the feeder.

Feeders.—Each bin above the boilers is built with two hoppers, each hopper supplying the feeder. In all there are 22 feeders in use, all of the screw conveyor type. One of the dryers and a 300-HP. boiler are equipped with Santmyer feeders. Two of the 300-HP. boilers, two of the 400-HP. boilers and one 600-HP. boiler are equipped with Fuller feeders. The other dryer, one 300-HP. boiler, one 400-HP. boiler, one 500-HP. and one 600-HP. boiler are equipped with Locomotive Pulverized Fuel Co.'s feeders. All are designed upon the same principle, the coal passing from the hopper into the feeder, where it is conveyed horizontally by means of the screw to a vertical outlet pipe, varying in size from 4-in. to 6-in. in diameter. Upon reaching this pipe a current of air, introduced through a 3½-in. diameter auxiliary air feed pipe, carries the coal downward directly to the burner. This air current is supplied by two Sirocco fans of 50,000 cu ft. per minute capacity each. They are located at opposite ends of a large supply duct from which all the feeders branch. Air is supplied to the feeders under a static head discharge pressure equal to 10 in. of water. In addition, two 3,000 cu. ft. per minute Sturtevant fans supply several individual feeders. These small fans are directly connected to 11 HP. Moore steam turbines. The larger fans are directly connected to 67-HP. Moore steam turbines.

The Fuller and Santmyer feeders are equipped with 1½-HP. Crocker-Wheeler Direct Current Motors, having a variable speed of 300 to 900 R.P.M. back geared to a countershaft. The feeder is chain driven in both types; the Santmyer feeder has a speed of 125 to 150 R.P.M. for ordinary operation, and the Fuller feeder a speed of 100 to 150 R.P.M. under normal conditions, depending on the size of the boiler being supplied and the load carried.

The Locomotive Pulverized Fuel Co.'s feeder is equipped with a specially designed General Electric direct current motor, which is directly connected to the feeder. This feeder operates at a much lower speed owing to the shorter length of conveyor, which with high speeds will flood. The motor has a variable speed of 500 to 1,500 R.P.M., rated at 1½ HP. at 230 V. and 6.95 Amp. The feeder has a speed of from 30 to 60 R.P.M. under normal operating conditions. The feed is regulated entirely with the motor controller, the connection between the hopper and the feeder being at all times open. The air supply is regulated by means of valves in the air feed lines.

Burners.—The burner is nothing more than a specially designed elbow with three openings, one for the fuel coming from the feeder, another smaller one for the additional air feed, and the third for the discharge into the furnace.

Following a series of experiments with various types of burners, the Santmyer burner was eventually installed throughout the entire plant. It was found that due to the shape of the furnace, better results were obtained by placing the burners below the floor.

Dutch Oven.—A "Dutch Oven," 5 ft. x 6 ft. x 7 ft high, was added to each of the boiler settings to increase the size of the combustion chamber. However, from careful observations made at this point, depth, rather than a large cross-section, is the essential factor in the proper combustion of pulverized coal.

Combustion Chamber.—The dimensions of the combustion chamber proper are approximately 14 ft. 6 in x 8 ft. 6 in. x 5 ft. high, including the "Dutch Oven." These dimensions, particularly the height, increase with the larger boilers. The sloping section of the chamber has a depth of 6 ft 6 in. and reduces to a cross-section of 3 ft. x 3 ft. at the bottom, where it enters the ash pit. The ash pit is 4 ft. x 4 ft. in cross-section and has a clear height of 3 ft. 6 in. The ashes are removed through a heavy cast iron door, lined with 4-in. fire brick. The entire combustion chamber is constructed of reinforced concrete up to the boiler room floor, or approximately a foot below the top of the sloping section. Above this line the original brick construction is encountered. The special brick lining consists of a 4½-in. thickness of Sil-o-cel brick and a 13½-in. thickness of first-class fire brick.

The excessive heat in the ash pit, which to a certain extent radiates through the front face of the same, made the handling of the ashes very difficult. To remedy this, an additional concrete wall was constructed in front of the original wall with an air passage between. This passage was left open at the top, thus permitting the radiated heat to pass upward and escape without interfering with operation.

Ash Crusher.—The resulting ash varies in composition from fine powder to exceedingly hard slag, but the largest percentage consists of rather soft clinkers. Some ash accumulates on the back slopes and wall of the combustion chamber as soft slag and clinkers, and a small amount is deposited back of the bridge wall as a fine powder. The major portion of it falls into the ash pit, from which it is raked at regular intervals and allowed to cool, preparatory to crushing.

The jaw crusher is set up on trucks with the feeder platform level with the bottom of the ash pit. The car travels upon rails and is driven by a 5-HP. direct current motor; the crusher is operated by the same motor. With five boilers on each side of the firing aisle, this crusher car serves all the furnaces. The basement floor is depressed 4 ft. between the boilers, to permit sufficient clearance for the crusher and the drag chain conveyor into which it discharges. The crusher reduces the ashes and clinker to 1 in. and smaller, so that it can be readily handled by the drag chain and elevator.

Drag Chain Ash Conveyor.—The drag chain conveyor is located in the bottom of the depression, extending along the entire length of the trench, approximately 100 ft. in length. It consists of a 12-in. link drag chain traveling in a heavy cast iron trough. It is driven by a 5-HP. motor. The drag chain conveyor discharges into a chute which leads into the ash elevator.

Ash Elevator.—The ash elevator consists of a single strand chain with 6-in. x 10-in. buckets, enclosed in a steel casing. It is driven by a 5-HP. motor from the head shaft. As the top of the elevator extends 15 ft. above the roof of the building, a chain drive is used, the motor setting on the roof. The capacity of the ash handling equipment is limited to the capacity of the crusher, which is 5 tons per hour.

Ash Bunker.—The ash elevator discharges into a spout leading to the ash bin, which is constructed of reinforced concrete and has a capacity of 110 tons. The bin is subdivided into two hoppers with three sloping sides and the fourth side vertical, being the one to the rear of the building; this brings the opening at the bottom of the hopper on line with the vertical face and permits of the use of a vertical sliding gate.

A platform has been built, from which the gate can be operated by means of a lever. As the rear of the building adjoins the railroad tracks, the steel chute used to convey the ashes from the bin is hinged in place so that when not in use the chute is raised by means of a block and line. The ashes are hauled away in trucks.

Miscellaneous Construction.—A sump pump driven by a ½-HP. motor takes care of the seepage in the raw coal crusher pit. Another pump driven by a 1-HP. motor takes care of the seepage and drainage into the mill room. A third sump pump driven by a 2-HP. motor removes the seepage and waste water from a sump which collects the water used in cooling the ashes.

Boilers No. 1 and No. 11 are connected to steel stacks of sufficient height for natural draft. The stack connected to boiler No. 11 was erected during the summer of 1918, has a diameter of 5 ft. and a height of 80 ft. The remaining boilers are connected to a low steel stack, draft being induced by a 11-ft. diameter by 5-ft. wide Sturtevant fan driven by a 50-HP. motor. This motor was installed during the summer of 1918, being located upon the roof of the boiler room, to avoid the excessive heat above the boilers. It is enclosed in a corrugated iron motor house.

To the rear of the mill room is located the transformer room, where the alternating current is stepped down from 2,200 volts to 220 volts. In addition to the transformers the switchboard for the plant is located here. A garage has been constructed at the rear of the building for the ash truck.

Operation.—The culm is loaded at the mine directly into the coal cars by use of a Bagley scraper, operated by a double drum hoist driven by a 125-HP., D. C. motor. A single span truss with a solid floor having an opening to permit the coal to drop into the car below, is erected above the railroad track at right angles to the same. The Bagley scraper hauls the coal to the opening where it drops into the car.

The coal is delivered to the storage bunkers at night, two additional men being furnished to help the train crew in unloading the cars. One man takes care of the raw coal equipment, coal being transferred from the storage bunkers to the crushed coal bunkers during an 8-hour shift sufficient for the 24-hour run. One man looks after the feeders into the dryers, which, owing to the higher temperatures at the discharge, tend to clog up. Another man operates the dryers and mills. He has an assistant who looks after the distribution of the dry coal and pulverized coal in the bunkers above.

Both mills and dryers are operated continuously. Pulverized coal is used as the fuel for drying; approximately one ton of pulverized coal being burned to dry 20 tons of the raw coal. The ashes are removed from the dryer settings through openings at the floor level. The driver must necessarily be shut down during this operation, which occurs at intervals varying from five to eight days.

The water tender also takes care of feeders, which are regulated by controllers located on the boiler room floor. The machinery is kept in operating condition by an oiler. Two helpers keep the tubes clean by operating the soot blowers and the use of a special steam jet inserted through the front of the setting. This operation is performed at four-hour intervals. In addition to this they also blow down the tubes.

Three additional helpers remove the ashes from the dryer settings, clean the combustion chambers when necessary and remove the ash deposit back of the bridge wall at regular intervals. This deposit is wetted down in the setting to facilitate handling and to avoid spreading of dust. It is taken out through the cleanout doors, loaded in wheelbarrows and dumped into the ash elevator. One cleaning per week is sufficient to take care of this deposit. The slag accumulating on the sides of the combustion chamber is removed at intervals varying from six to ten weeks, depending on operating conditions.

The ash falling into the pit below is removed with long rakes. The ashmen look after this work, while the third operates the drag chain and ash elevator, and feeds the ash crusher. The ash as found in the pit consists of slag and powdered dust. The slag is pulled out near the door and cooled off with a stream of water. When sufficiently cool it is pulled out onto the runway in front of the ash pit, where it is again drenched to speed up the cooling, after which it is fed to the crusher.

With the exception of handling the raw coal and removing the deposit back of the bridge wall, which work is taken care of by a single shift, all operations are continuous, being carried on with three shifts working eight hours each.

Increase in Cost of Living in Foreign Countries.—In a recent issue of the Paris edition of the Daily Mail, the following figures are quoted from a report made by the Statistical Bureau of Berne, Switzerland, which represent the increase over pre-war prices in certain countries: Italy, 481 per cent; France, 368 per cent; Switzerland, 257 per cent; England, 240 per cent

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Activated Sludge Plant for Chicago Stock Yards.—The committee of the trustees of Sanitary District of Chicago voted Sept. 3 to construct an activated sludge plant for the treatment of the trade wastes from the stock yards district. It also was voted to request the packers to pay two-thirds of the cost of installation and operation.

The Application of Industrial Efficiency*

By CHARLES E. BEDAUX,
Charles E. Bedaux Co., Industrial Engineers.

The high cost of living and high scale of wages—should they remain? And if not to remain where is to be the change? We contend that the wages, outside of some adjustments, will remain the same.

We think that the Europeans have a reconstruction period which awes and terrifies, but it is in my mind a question whether we have not ourselves a reconstruction period which is as important if not more important. I heard a soldier the other day on the train state that he did not think much about France. He had gone from the ocean to the battle front and he has seen nothing but vineyards and two factories, and those two factories made brandy. But he didn't pass the right way. There are factories today in France that are as large or larger than most of our industrial groups in the United States. One of the large factories of France started a little over four years ago and now employs over 45,000 men and women. This factory is supplied with the very best facilities for the welfare of its employes, including dentistries and nurseries for children, as so many married women work there.

With the signing of the peace treaty France has more blast furnaces than Germany ever had. France has learned Germany efficiency through a great deal of sorrow, and is now bent upon turning her new knowledge, with her new facilities, with her new coal deposits from the Saar basin, and the steel from the Briey district, into standardized products, capable of being manufactured and sold in competition with the most advanced American industry.

The Wage Scale of Europe as a Factor.—American efficiency, typically an American institution, is more interesting to England at the present time, it appears, than it is to this country. Motion studies are actually practiced, and not talked up in that country. It is useless to talk of Germany. You have read the peace treaty or, rather, a summary of it, but it must not be forgotten that the Germans remain. They will no longer be taught the goose step, but will continue to follow their industrial organization, which is almost unequaled and will be held by iron discipline which seems to continue even through their revolution.

When you consider that those countries manufacture articles at a cost of labor which is 2 ct. where it is three to us in the United States, we wonder where we will sell our goods in five years from now, if we are to utilize that which we have built during this war, to supply Europe and supply our own needs. Thirty-three per cent difference in the scale of wages is not easily offset and something radical must be done.

While a protective tariff may conserve our industries for our own needs, it will not be possible for us to go into South America or to go on European soil in competition with a modern Europe, having new ideals, new methods, taken and learned through study from our Ameican engineers and business men during the war, who have shown them what organization should be. It will not be possible for us to compete with those and we shall either have to stay home or find some other way out.

Efficiency Best Solution of Problem.—The question is, what is the way out? We find it through efficiency. What is efficiency? To many of us it represents a planning department, a planning room that stands in the middle of the shop, or in some corner, with a great deal of importance; and this planning room attempts or claims to attempt to send work through the shop at given times so that it may leave one machine at a certain hour and reach another machine at another hour. I might ask the question: how can I tell how much time it will take me to get home if I don't know the distance, nor the conditions I will be in when I am ready to go home? This information is essential.

One has to know exactly what he is going to do before he can expect to plan. This is determined, many will say, by the setting of standards. But, then, how are they set, and how are they used? I have personally gone into many factories, perhaps 50 new ones each year to visit, and 12 each year to work in. Out of the 90 per cent of planning departments that I have found in those industries I do not believe I have found 5 per cent that really have standards of time with which to work. The operator knows that and he is quite keen on his realization and appreciation of that fact. He does not sympathize with the average efficiency movement, because whether the standard is used as a method of remuneration or whether it is used to plan the work through the shop, he loses confidence in the effort that he has made and he turns it more or less into ridicule. I can talk from experience.

American Labor Cost Must Be Reduced.—We contend that 33 per cent of the cost of labor must be reduced to offset the difference between American and European scale of wages. We cannot expect the European scale of wages to go up immediately, for we first will have to teach the European to use electricity or gas in his home, to take a bath once in a while, to have a telephone to call up market for goods, that sometimes come short, sometimes come good and sometimes come badly.

The average European woman goes to market and spends half a day trying to save 3 cts. and walks back with the load so as to save car fare, which is 3 cts. Here the average wife or the workingman has a telephone and calls to the market, therefore, having less chance of selection. That alone increases the cost of living—the lack of selection which decreases the quantities received, the lack of specialization in choice, which removes education along that line. So unless we take all that away from the European—the French, the British, the Italian lady—and the many discomforts that her husband acepts after his work, and unless we do away with the millions of women who in Europe today are expert mechanics, having learned through four years of intensive labor—unless we take those away we shall have to find some other means of reducing this 33 per cent in cost of labor.

It must be through efficiency, and yet it should be through an efficiency which is different from the one I just mentioned—the one of setting standards without particular knowledge of them, through practices that operators know and more or less despise. Then how will it be? Will it be through method? And what is method, systems, records in a plant? The first consideration in a factory, you will agree with me, is to have the men happy. If they are not happy you cannot have an efficient production. What is the second consideration? Production—turning out the finished product. It must therefore be realized that any method, any system, must be secondary to production, to manufacture. When it is well determined that production is supreme and that method is secondary to it, and anything other than method has been removed, then that method or system must be followed.

It is unfortunately the case that the practical man finds so often that a portion, and a large one, of that systematic way of routing or carting things through the shop is hampering production, and he therefore sets aside all or a portion of that system. At that time it must be remembered that once it is determined that the method or system adopted is secondary to production and is used to serve it, that system or method must be used as a whole. It is far more injurious to use a portion of it than not to use it at all.

Efficiency Needs Practical Men.—In the days of our forefathers they had to serve a 5-year apprenticeship, and when a person became a master worker the boss knew to a unit just how much he could produce in a day, for all he did was with his hands. Today conditions demand new standards. A machine makes 500 pieces where a man use to make 10. We soon forgot the fact that a man used to make 10. We only knew that the machine could make a whole lot. But one competitor using the same machinery is getting 400 and the other one, having such a combination of machines, gets only 300 and has to pay aginst his cost a burden on the machinery he had purchased, finds himself out of business, although that machinery manufactures a great deal more than the man by hand used to do. For that reason there is a need of order, there is a need of system and method, but it must remain secondary to the manufacture itself.

There is nothing more detrimental to industry than to see in the shop many colored cards and sheets going all over without any other purpose than to furnish employment to befoggled young men who have not much else of interest

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*From an address presented before the Industrial Association of Cleveland.

The average man with a white collar when he gets into a factory where it is more or less noisy has only one feeling, and that is to get out. There are many men today who cannot think at all when their hands get dirty. It gives a certain superiority to the shopmen, a superiority which is often distinctly shown. It has a great deal to do with the discredit into which many of the system fall. Those systems hampering production, causing discontent, should cease to be It is strange for an efficiency man to come and tell you that those systems should end. They should. If men unfamiliar with manufacture have adopted or presented methods supposedly to help manufacture, and are falling short of their expectations, it becomes the duty of the manufacturing man, or the workingman, to take the place and add to this manufacture whatever means are necessary to make it systematic. To just look at it and say, "It is no good and will not work, and I know it will not work," is no justification. The thing to do is to take it and make it go right.

What efficiency needs today is practical men with the knowledge of the shop who will learn the possibilities of improving production and becoming efficiency men themselves and not be afraid of the name, for it is in that way and only in that way that we can reduce the cost of production, as we must reduce it within a short time.

Fundamental Knowledge Necessary for Application of Efficiency.—The application of efficiency to industry with a view to reducing cost has been largely limited to that—the various means of routing or checking or planning the manufacture of the work through the various shops. It has done so without the fundamental knowledge which is absolutely necessary—measurement, knowing what are the units, if there are any, that can govern the relation of that which has to be done with that which is today the thing that has to be done, that is, planning.

Planning is a well-ordained intention of doing one given thing at a given time under given conditions. Now, can we as a rule plan work through manufacture? Have we the information that will make that possible? And when it is done will it give the maximum result, the maximum production for a given effort? We contend it does not.

The efficiency man of today, instead of sitting in the office of the planning department or in the executive office, should go through the shop to find out—not for the workmen but with the workmen—how long it takes to do a thing, whatever that thing may be; to agree with them that it does take that long, and once it is determined to put it down into a record that under given circumstances it has taken and it should take that long to perform that given operation, and then pass on to the next operation with that other man and that other machine, and so on through the shop.

Time Studies Essential.—Take those time studies with the foreman, analyze them with him; take up the question of toolings, if there are any to be taken up, and the question of material being brought or taken away, if it is a matter of arranging work, and then arrive at a knowledge which is essential, which will show three things—the time required to perform, the capacity of that which performs, if it is a machine, and the weaknesses in the performance if it is properly timed.

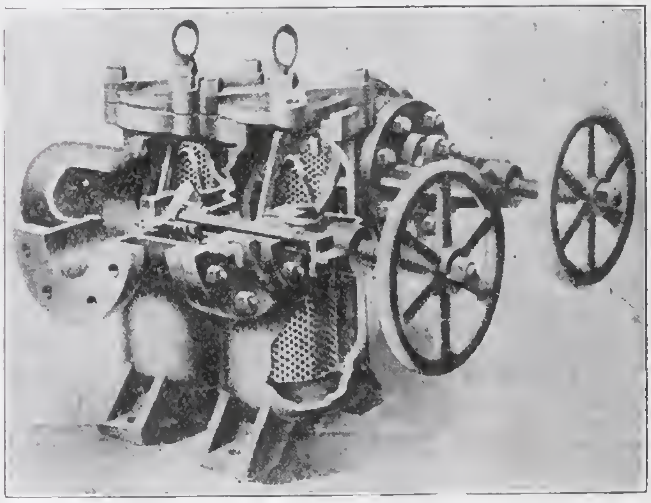
In the operation it will give an actual time to perform under given conditions. If that actual is then combined to a period of rest, as no human being can be expected to work all day long without any rest, a certain figure will be reached. We will say, for instance, a milling operation —hand mill—and it has taken for that particular job 2½ minutes, but it is agreed by the operator and the foreman that there was a certain waste time, not wasted by the operator necessarily, but wasted through the process, through the nature of the operation, or through conditions of tooling, so that the actual time under normal conditions is two. Then add to that a certain percentage, we will say in this case it is one-half for rest and delays, so that the total will be four. Suppose instead of doing it with one operator you had done that 1,000 years ago with 1,000 men, all average men, and had given them a certain operation to perform and had determined the individual time, had taken the waste and combining the time of a thousand and dividing by that number you had arrived at an average time to perform, and you were to repeat that same experiment today with a thousand men, you would arrive at practically the same thing, for individual length of time does not change.

I do not speak of equipment; I do not speak of facilities; I speak of time as an average running through the ages. Whatever time you have set, if it is 4 minutes on that milling operation, and if the metal runs the same, and it is the same metal under the same conditions of light, heat and so forth, whatever time you put it in the future it will require the same time as it does today.

In other words, the standard of time does not change unless the operations or the conditions that govern the operations change themselves. If it does not change, then why not use it as a constant, as a means to measure that which is done? If the efficiency man who himself is a shop man, familiar with the lines he goes into, with the help of the operator and the help of the foreman arrives at an average time to do a certain thing, isn't that a form of measurement? Suppose that you have arrived at 4 minutes; just to be different call it four points: What is an inch? An inch is a twelfth of a foot. What is a point? We call the point the fraction of a minute of work plus a fraction of a minute of rest, the aggregate of which makes one minute. That becomes a unit, a unit to measure by. And if we were to have today units of measurement on all operations that are performed, we could dispatch the wrok through the shop. We could remunerate labor without any differences or difficulties, and we could secure an increased production that would probably offset the difference in cost of labor between our allies and friendly competitors of the future.

Strainer for Oil Systems and Water Supply

A duplex strainer, designed for installation in the suction or discharge lines of lubricating or fuel oil systems for the removal of solid foreign material in suspension has been placed on the market by the Griscom-Russell Co., 90 West St., New York. Such foreign material, if not removed, makes the lubrication inefficient and may seriously damage bearing surfaces. Similarly, sediment in fuel oil tends to clog the burners, reducing their capacity and necessitating frequent cleaning. This strainer is also suitable for straining the water supply from such sources as rivers and lakes to prevent weeds, sticks, marine plants and small fish from entering the pipe lines. The strainer consists of a cast iron body containing two perforated steel or brass baskets. The valve arrangement permits of the complete removal and cleaning of either basket while the other remains in service. In operation the oil or other liquid enters the inlet connection of the strainer and passes into whichever basket is in service. The solid matter remains in the basket, the clean liquid passing through the perforations and thence out of the strainer. All cast iron sections are cylindrical, resulting in maximum strength. The valve mechanism is very simple and the valves are easily re-ground.

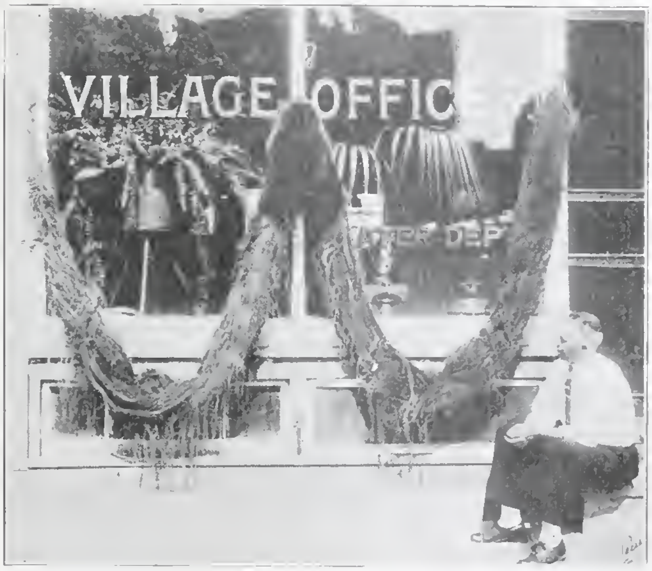


G. R. Duplex Strainer.

Root, 24 Ft. Long, Taken From 10-In. Water Main

The accompanying cut shows a willow root, 24 ft. long, taken out of a 10-in. wooden water main of the Avon Water Works at Lakeville, N. Y. It was fed from a root about the size of a lead pencil, which came from a willow tree, 3 ft. in diameter, growing near the water line. The root entered the pipe through a wooden plug which was driven about 20 years ago. It is supposed that a very small fiber or tendril of the root was driven in with the plug at that time.

Last fall it was noticed that the head of water at the chlorine plant at Millville, which is over a mile from where the root was taken out, was not up to normal. The cause was attributed to a number of different reasons, among them a leak in the conduit, between that point and the reservoirs; a leak between the chlorine plant and Lakeville or a stoppage between the two latter places.



24-ft. Long Willow Root Taken from 10-in. Water Main.

A leak in certain places would be difficult to locate as the conduit follows closely and crosses the Conesus Lake outlet 13 times, from the lake to Avon, a distance of over 8 miles. Tests were made with coloring fluid and the creek crossings were closely watched without discovering any leaks. The Water Commissioners and the superintendent therefore decided that the source of trouble was above the chlorine plant at Millville. Tests were made and levels taken from the chlorine plant to the lake and the stoppage located. The big root approximately shut off two-thirds of the supply of water.

As the conduit was located very near the outlet and from 4 or 6 ft. below the creek level, work was difficult, but through the kindness of the Rochester Water Works, William H. Clark, superintendent of the Avon Water Works, was able to borrow a large trench pump, which took care of the large amount of seepage [illegible] flowed [illegible] creek.

In order to remove the root from the conduit [illegible] about 8 in. by 10 in. was sawed from the top of the pipe. [illegible] small rope was then fastened around the head of [illegible] and it was pulled out by three men.

Newark, N. J., to Dispose of Garbage by Feeding to Swine

A contract for the purchase and final disposition of garbage by feeding was awarded by the city of Newark, N. J., on July 3, 1919, for a period of 5 years, commencing Sept. 1, 1919, to the National Utilization Co., Arthur N. Pierson, president, Woolworth Bldg., New York City. The price to be paid to the city for each ton of garbage delivered is 8 times the price per pound of live killing hogs on the Chicago market, as determined by averaging the top price for each month.

The site of the piggery is located along the shore of the Passaic River and the city wagons are to deliver all garbage to the feeding site, where it will be weighed. The city agrees to the enforcement of existing ordinances, by orders or otherwise, to effect a good primary separation, and also agrees to endeavor to pass ordinances whereby the contractor will receive all hotel and restaurant garbage.

The collection of all city refuse was done by contract until 1916, when the contractor terminated the contract on the grounds that the separation ordinance was not enforced. It was then taken over and carried on by municipal forces. There has been some attempt for several years past to separate garbage from other refuse, but it was rather unsuccessful. In March, 1919, a new ordinance was introduced requiring the separation of ashes, rubbish and garbage. At the present time separation is effective in about 50 per cent of the city. A police officer and inspector are assigned to each district to enforce this ordinance, and the results have been very gratifying. Separation in the remainder of the city will be completed about Sept. 15, 1919.

The erection of a reduction plant of a 150-ton capacity was contemplated, but in view of the present cost of building material it was considered prohibitive. An estimate received from one company was $750,000 exclusive of the site. The city has some 6 square miles of meadow land and all classes of refuse have formerly been dumped on this land. There is a contract for the salvaging of the material for which the city receives $3,000 annually for the privilege, in addition to which the contractor supplies all labor necessary to keep the dumps and the roads leading thereto in good working condition. When separation is completed in the entire city it is planned to erect a utilization plant for rubbish and when this is realized only ashes will be deposited on the meadow land. The area of the city is 23 square miles and the estimated population is 450,000. It is estimated that 5,000 hogs will be required to consume the maximum amount of garbage during the peak months of summer.

On account of the limited area available at the site of the piggery, intensive methods will be employed. The hogs will be housed in unit buildings 100x100 ft., which will accommodate from 800 to 1,000 hogs. A double concrete driveway and feeding floor 24 ft. wide extends through the center of each building with a gutter on each outer edge next to pens. The gutters discharge into large grease traps to prevent solids reaching the sewer. The pens are arranged on either side of the driveway, having a slight pitch toward the gutters. There are five pens on each side equipped with an automatic drinking fountain. Each pen opens into a yard [illegible]

Water Rates in 13 Large American Cities.—The following table reprinted from the 9th annual report of the Board of Public Utilities of Lons Angeles, Cal., for the year ending June 30, 1918, shows the comparative water rates prevailing at that time in 13 large American cities:

	Services.		Annual Flat Rate			
	Total	Metered	Residence	Business	Minimum	[illegible]
Baltimore	120,700	4,353	[illegible]	[illegible]		
Buffalo	89,809	1,353	9.00	[illegible]	(f) 5.00 (annual)	
Cleveland	104,311	101,668	...			
Indianapolis	18,118	5,221	2.50	(b)	[illegible]	
Kansas City	62,000	45,000	[illegible]	...		
Milwaukee	64,968	61,325		...	[illegible]	[illegible]
Newark	48,158	12,405				
New Orlenas	54,000	[illegible]		...		[illegible]
Portland	61,333	17,152		[illegible]		[illegible]
Saint Paul	42,250	36,330	[illegible]	b)	30 (f)	
Seattle	44,436	43,636		...		
Washington	70,475	60,423	[illegible]	b)	[illegible]	
Los Angeles	109,629	95,000		[illegible]		

NOTE:—All plants municipally owned except that at Indianapolis.

NOTE:—(a) Graded on Frontage—amount shown on 50-ft. (b) Graded on [illegible] Rates on [illegible] number of rooms and fixtures. (d) Minimum—additional charges graded on frontag[illegible] amount shown for four rooms. (f) Graduated minimum, depending on size of meter.

The houses are of the saw-tooth type with windows the entire length below the eaves and in the peak.

James W. Costello is Engineering Supervisor of the Bureau of Street Cleaning and Refuse Collection of Newark, N. J.

Cost of U. S. Irrigation Projects and Crop Values

The accompanying table from the August Reclamation Record, shows, by projects, the net cost of construction on June 30, 1918, and the gross value of crops grown on the area covered by crop statistics. This gross figure, large as it is, as far below the actual amount, as the crop census does not cover, for example, considerable areas of land under canals built by private parties and related to the Government projects through contracts under the Warren Act, by which they share in various degrees the benefits of the Government works. In most of these cases the storage works are used in common occasionally the diversion works and main canals and part of the water stored or diverted by the Government is delivered in bulk to the private canals or irrigation districts, which provide their own distributaries and operate them.

It should be noted, in those instances where the crop value appears small in comparison with the cost of the project, that this is due usually to the fact that irrigation is available for only a small part of the project at the present time, for example, in the cases of Grand Valley and Milk River; or only a small part of the project may be irrigated, as in the cases of Sun River and Lower Yellowstone; or the irrigation system was not fully operated, as in the case of King Hill.

State and Project.	Net cost of construction June 30, 1918.	Gross crop return.
Arizona, Salt River	$ 11,541,507	$18,188,800
Arizona-California, Yuma	8,972,508	5,105,132
California, Orland	893,289	709,172
Colorado:		
Grand Valley	3,238,470	413,310
Uncompahgre	6,554,465	3,302,460
Idaho:		
Boise	11,688,830	5,154,646
King Hill	170,000	45,588
Minidoka	5,720,690	5,168,078
Montana:		
Huntley	1,705,490	750,963
Milk River—		
Distribution units	3,173,979	408,716
St. Marys storage unit	2,417,913	
Sun River	3,424,313	245,852
Montana-North Dakota, Lower Yellowstone	2,891,205	669,191
Nebraska-Wyoming, North Platte	9,265,320	3,475,589
Nevada, Newlands	6,199,459	1,626,142
New Mexico, Carlsbad	1,386,417	1,105,515
New Mexico-Texas, Rio Grande	7,699,391	4,237,020
Oregon, Umatilla	2,344,004	400,642
Oregon-California, Klamath	2,913,053	929,131
South Dakota, Belle Fourche	3,455,239	1,276,115
Utah, Strawberry Valley	3,443,962	1,642,327
Washington:		
Okanogan	848,578	749,982
Yakima—		
Storage unit	3,607,065	....
Sunnyside unit	3,266,216	7,213,392
Tieton unit	3,197,775	2,516,251
Wyoming, Shoshone	5,450,385	1,486,382
Total	$115,469,523	$66,821,396

Registration of Technical Engineers in Oregon

The Oregon State Board of Engineering Examiners has completed its organization and is now prepared to receive applications for registration of the professional engineers in Oregon, and others who expect to practice engineering in Oregon. The personnel and officers of the board are as follows: F. S. Baillie, Baker, Mining Engineer; R. R. Bartlett, Astoria, Civil Engineer; G. A. Covell, Corvallis, Mechanical Engineer; W. B. Dennis, Carlton, Mining Engineer; F. Hesse, Portland, Mechanical Engineer; E. G. Hopson, Portland, Hydraulic Engineer; O. Laurgaard, Portland, Civil Engineer; J. H. Lewis, Vale, Hydraulic Engineer; F. D. Weber, Portland, Electrical Engineer. The following officers have been elected to serve for the next biennium ending July 1, 1921: O. Laurgaard, City Engineer of Portland, president; F. D. Weber, Electrical Engineer for the Oregon Insurance and Rating Bureau, vice president; A. B. Carter, Civil and Mining Engineer, secretary. Headquarters for the board have been established at 520 Corbett Bldg., Portland, Ore., where the necessary application blanks for registration without examination, and copies of the law and all other information may be received at request. Under this legislation, which went into effect July 1, applications are divided into two classes: those for registration without examination and those for registration consequent to examination. For those who expect to be registered without examination the applicant must show that he is more than 21 years of age, that he is of good character, and has practiced professional engineering for at least six years, and that during that period he has had charge of engineering work as principal or assistant for at least two years. All statements made by the applicant must be attested by him under oath, and in addition the applicant must submit evidence, satisfactory to the board, of the accuracy of the statements submitted by him.

The professional engineers who expect to practice after Jan. 1, 1920, according to the law must be registered, so it is very important that the applications of not only those who expect to be registered without examination, but also those who expect to take the examination should be in before that date.

Personals

Oscar Dubbs has been appointed city manager and city engineer of Clovis, N. Mex.

Herbert L. Kidd, Knoxville, Tenn., has been elected city manager of Kingsport, Tenn.

Capt. Carl D. Forsbeck has been reappointed county engineer of Montgomery County, Iowa.

Clyde Morgan has been appointed director of the municipal water department of Fairmont, W. Va.

George Orr, until recently Captain of Engineers, U. S. Army, has been reappointed assistant engineer in the city engineer's office of Atlantic City, N. J.

Louis H. Laging has been appointed acting city engineer of San Angelo, Tex., succeeding Charles C. Smith, who resigned to superintend the construction of Schleicher County's improved roads

C. H. Johnson, chief engineer in charge of power stations of Columbus (O.) Railway, Power & Light Co., has resigned to accept a position as investigating engineer for the president of the Combustion Engineering Corporation of New York.

Capt. E. D. Hendricks of Fort Plain, N. Y., has been appointed division engineer in the New York State Engineer's department, with headquarters at Albany. He succeeds George D. Williams, who was recently appointed county engineer of Oneida County, New York.

Obituaries

James M. Torr, assistant engineer of the Providence Division of the New York, New Haven & Hartford R. R., died Sept. 1, aged 66.

William C. Nusser, superintendent of the municipal waterworks of Findlay, O., was killed Sept. 2 in an accident resulting from the fall of a derrick.

Industrial Notes

The Chicago Pneumatic Tool Co. announces the appointment of Fred Gehbauer as special navy yard representative, with headquarters at the Philadelphia office, 1740 Market street.

The Lakewood Engineering Co. announces the appointment of Harry W. Benkart as its representative in Buffalo, N. Y., with offices in the Ellicott Square building. Mr. Benkart will devote his efforts to the general construction field. He has had about 10 years' experience in the construction business, the greater portion of which time he spent as superintendent of construction of the Dravo Construction Co.

The International Factory Appliance Exposition, which opens Oct. 15 in Grand Central Palace, New York City, will occupy the entire sixth floor of that building. It will be one of the eight permament industrial expositions in the Palace operated by the Merchants' and Manufacturers' Exchange. The display will include exhibits of material handling machinery, power plant equipment, transmission machinery and all sorts of accessories, tools and appliances for the modern factory, terminal and warehouse.

Otto A. Ruemelin, works manager and second vice-president of Pawling & Harnischfeger Co., Milwaukee, Wis., died Sept. 1. As a youth Mr. Ruemelin began his apprenticeship with the Pawling & Harnschfeger Co. After several years as journeyman he was promoted successively to the foremanship of various departments. His energy, ability and kindly nature made his rise rapid from assistant superintendent to superintendent and finally works manager, which position he has held since 1912. His death concludes a period of 30 years' association with the Pawling & Harnischfeger Co.

Capt. Lucius A. Fritze, Sanitary Corps. U. S. Army, has become associated with the technical staff of Wallace & Tiernan Co., Inc., New York City, manufacturers of chlorine control apparatus. Capt. Fritze, who was sanitary officer of the Rainbow Division, after the armistice was assigned to the office of the surgeon-general in Washington, and while there prepared a history of the Sanitary Corps of the A. E. F. Capt. Fritze will be the manager of a new office which Wallace & Tiernan Co. are opening at Kansas City, Mo., serving territory comprised in the states of Montana, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Kansas and Missouri.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Pumps.—Taber Pump Co., Buffalo, N. Y. 6-page circular describing an improved "G" type rotary pump

Boilers.—Kewanee Boiler Co., Kewanee, Ill New 32-page catalog of Kewanee firebox boilers, superseding all previous issues.

Valve Stems.—American Manganese Bronze Co., Holmesburg, Pa. 24-page catalog describing the use of manganese bronze in the stems or spindles of valves. Contains illustrations and descriptions of numerous large valve stems.

Air Wasting and Cooling Equipment.—Spray Engineering Co., Boston, Mass. 16-page bulletin illustrating and describing use of Spraco air washing and cooling equipment with steam turbine generators and other electrical machinery.

Railways and Excavation Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field if subscribed for as a weekly at $3.00 a year; but any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year (or any two monthly issues at $1.50 a year) and the 4 special quarterly issues will be sent without extra charge. Three of these special quarterly issues relate entirely to foreign engineering and construction practice, and the fourth is our annual "New Equipment Issue." The *articles* in the first two issues of each month (1st and 2nd Wednesdays) completely cover the municipal engineering and contracting field. The *articles* in the first and last issues of each month (1st and 4th Wednesdays) completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and last issues of each month (3rd and 4th Wednesdays) completely cover steam and electric railway location, design and construction. See the "mast head" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging (c) Quarries and Pits
(b) Rivers and Canals (d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings (c) Harbor Structures
(b) Bridges (d) Miscellaneous Structures
(e) Properties of Materials

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"How Many Hides Has a Cow?" How Many "Values" Has a Railway?

In the editorial entitled "How Much Have Street Railway Construction Costs Risen?" will be found the results from applying seven different methods of appraising the physical property of the Pittsburgh street railways. Bear in mind that the seven different "costs" thus derived do not include "development cost," "franchise value," or the like. Engineers have always differed considerably as to their theories of valuation for rate making purposes, but we have never before seen in one report as many as seven different theories of "cost new" of physical property.

Consider the dilemma of the public service commission when called upon to determine the definite "value," of the Pittsburgh Railways. They will have seven different physical "costs new" from which to select, to say nothing of "depreciated value," and probably not fewer than half a dozen non-physical costs and values to chose from. We leave it to our mathematical readers to calculate the number of combinations that may be secured from seven physical "costs new" and six non-physical "values."

Is this a carrying of engineering refinement to an extreme? Or is it merely evidence of a lack of knowledge of what is being sought? In our opinion these seven different methods of estimating the physical cost new of this railway system are not so much indications of hairsplitting as of working in the dark. Each engineer may have his own theory of what method should be used, but since he does not know what theory the commission or the court may adopt, he presents a basketful of theories, from which they may make a selection.

The Supreme Court of the United States has yet to lay down a basic rule for appraising a public utility for it has still to decide to what extent a public utility should be regarded as a public agent. If the agency is to be regarded as complete, then the actual investment in the property would probably be the rate making "value." If it is held that the agency has been so incomplete that rates were left to adjust themselves under competitive conditions, then the rate making value would probably be the commercial value [illegible] the capitalized [illegible] pective net earnings under competitive conditions. One [illegible] theory [illegible] actual cost [illegible] to values [illegible] these [illegible] there is [illegible] compromise [illegible] the struggles [illegible] engineers [illegible] ers and judges [illegible] to [illegible] effort to find [illegible] ical rate [illegible] value [illegible]

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

has been an agent. Of the seven different methods of appraising the Pittsburgh Railways, the first two (Basis No. 1 and No. 2) are founded on the "agency theory," as far as they go; whereas the last method (No. 4) is founded on the "competitive theory," for the most part, although not in its entirety. The other four methods are based on no definite theory of rate regulation.

Method No. 3A (estimated cost of reproduction new at average prices of 1906-1915, and under original conditions) might perhaps be regarded as a rough approximation to the actual cost. It is defensible on no other ground.

Method No. 3B (estimated cost of reproduction new at prices indicated for 1918 by the trend of prices for 20 years previous to 1918, and under original conditions of construction) falls under no economic theory known to the editor. Why the trend of prices prior to 1916 should be used to estimate a cost in 1918 is beyond our ability to explain.

Method No. 3C (estimated cost of reproduction new at average prices in the period 1914-1918, and under original conditions of construction) is also based on no rate making theory. In normal times a five-year average of prices has frequently been used to eliminate current price fluctuations; but this particular five-year period was so abnormal as to be useless for such a purpose.

Method No. 3D (estimated cost of reproduction new at the estimated average price for the period from 1918 to 1922, inclusive, and under original conditions of construction) is also based on no rate making theory. It is a sort of a "cross" between the "agency theory" and the "competitive theory," in that it selects the "conditions" that actually existed when the plant was built, but applies prospective prices during a hypothetical construction period.

It seems to us that the appraisal engineers should have made but two appraisals of the cost of the property, one based on the conditions and prices that actually existed when each part of the plant was built (which corresponds to their Basis No. 2); and the other appraisal based on prospective conditions and prospective prices during a construction period beginning April 1, 1918. The prices used in Basis No. 3D and the construction conditions in Basis No. 4 would have given this second appraisal with sufficient accuracy.

A compromise "value" between the actual cost of the plant and the prospective cost of a substitute plant, might then be arrived at by arbitrarily selecting a "value" between the two extremes. Any attempt to make a compromise appear scientific or logical is not good engineering, yet such an attempt is to be found in most of the seven methods under discussion.

How Much Have Street Railway Construction Costs Risen?

Few appraisals of steel railways have been made at present prices, hence special interest attaches to the recent valuation of the Pittsburgh (Pa.) Railways. The board of engineers that made this appraisal submitted to the Public Service Commission seven different "values" of the physical property, as follows:

Basis No. 1—Historical cost as determined upon from the records, with scrutiny of engineers and accountants, representing actual investment in physical property placed in the service of the public, $59,069,392.

Basis No. 2—Estimated costs of reproduction new at prices ruling when each part of the existing property was constructed and under original conditions of construction, $49,324,791.

Basis No. 3A—Estimated cost of reproduction new at average prices of the period 1906 to 1915 inclusive, and under original conditions of construction, $56,148,398.

Basis No. 3B—Estimated cost of reproduction new at prices indicated for 1918 by the trend of prices for twenty years previous to 1916, and under original conditions of construction, $60,832,200

Basis No. 3C—Estimated cost of reproduction new at average prices in the period 1914-1918 inclusive under original conditions of construction, $73,560,300.

Basis No. 3D—Estimated cost of reproduction new at the estimated average prices for the period from 1918 to 1922, inclusive, and under the original conditions of construction, $84,191,300.

Basis No. 4—Estimated cost of reproduction new at prices and under the conditions ruling at the date of valuation, viz., April 1, 1918, $102,842,274.

"Intangible values" are not included in the above totals. It will be noted that the cost of construction and equipment as of April 1, 1918, is more than double that shown in "Basis No. 2," and 84 per cent in excess of that shown in "Basis No. 3A."

In estimating the probable annual expense of maintaining electric railways, the average annual maintenance expense of prewar years should be expressed as a percentage of the plant cost; then this percentage should be multiplied by nearly two, to allow for the rise in wages and prices. Similarly in estimating a depreciation annuity, the percentages used prior to the war should be approximately doubled, unless it is proposed to charge to plant account the cost of each new plant unit in excess of the actual cost of the old unit replaced by it.

From the records of a good many street railway lines, the editor has found that combined repairs, renewals and accrued depreciation have averaged annually 7 per cent of the total plant cost. This is on a sinking fund basis for renewals of plant units. If from 7 per cent of the plant cost there is deducted the actual expenditure for repairs and renewals, the balance is the amount to place in a depreciation fund. But, as above indicated, it will be necessary either to multiply the 7 per cent by the probable future cost of reproducing the plant, or to multiply the 7 per cent by a factor that is the ratio of the probable future cost to the actual cost.

Ill-informed politicians of the type to which we have referred in another editorial, having not the vaguest conception of the economics of public utilities even in normal times, are more foolish now than ever in their efforts to please the public by promise of low rates.

The Seattle Municipal Railway Is No Gold Mine Either

Mayor Thompson of Chicago says that he will "fight to the last ditch" the 7-cent street car fare recently put into effect by the Public Utilities Commission of Illinois. Ex-Governor Foss, of Massachusetts, has announced that he will be a candidate for Governor on a platform of municipal ownership of public utilities and 5-ct. street car fares. These two politicians are typical of hundreds that are catering to the public desire to get something for nothing; for if an equitable street car fare is 7 ct., then a 5-ct. fare gives the passenger 2 ct. for nothing.

Frequently the proponents of municipal ownership point to the 5-ct. fare on the municipal lines in San Francisco and Seattle. But if they will keep on pointing and if the public will keep on looking, those two American experiments in city operation of street cars are likely to deter other cities from making similar experiments.

After allowing for lost taxes and for depreciation, neither the San Francisco nor the Seattle municipal railway is earning enough to pay bond interest. For the fiscal year ending June 30, 1919, the San Francisco municipal railway did not show true net earnings (after allowing for lost taxes and depreciation) of 1.5 per cent on the $6,000,000 investment in the plant; and the coming year will be even worse, unless the fares are raised.

The city of Seattle bought the street car lines for $15,000,000 and began operating them April 1, 1919. The financial results for the quarter ending June 30 are as follows:

Gross revenue	$1,299,039
Operating expenses	1,052,727
Balance	$ 246,312
Damage claims ($20,000) and industrial insurance ($20,722)	40,722
Apparent net revenue	$ 205,590

From this should be deducted lost taxes (which would be $300,000 a year it they were as low as 2 per cent on the $15,000,000) and depreciation (which would be $300,000 a year, if estimated at 2 per cent). The city states that an average for depreciation would ordinarily be $300,000 a year, but that maintenance charges during this quarter were nearly $100,000 greater than during the corresponding quarter of the previous year; hence the no depreciation annuity need be set aside. The editor questions the correctness of this reasoning, for, in addition to heavy current maintenance, there should be fully 2 per cent per annum set aside for a depreciation reserve.

The apparent net earnings are $205,590 for the last quarter, or about $820,000 a year; but if we deduct $600,000 for lost taxes and depreciation, there is left only $220,000, or about 1.5 per cent on the investment.

Los Angeles is talking municipal ownership of the street railways, and it is to be hoped that the city will buy the traction lines. Then the three largest cities on the Pacific Coast will be operating street railways. and the country at large will have a chance to see the best that can be looked for in municipal ownership. It is to be hoped, also, that Massachusetts will approve the platform of Governor Foss, and try municipal ownership. By all means let us have a thorough trial of public ownership of public utilities in several states. But, in doing so, every city should be required to show both the "lost taxes" and an adequate depreciation annuity in its financial statements, as San Francisco does. Then the economic performance of municipal plants may be judged with some approach to accuracy.

The Growing Deficits of the Telegraph and Telephone Lines of Great Britain

The Government-owned telegraph and telephone lines of Great Britain have been frequently referred to by Postmaster General Burleson as examples of efficient public operation of public utilities. In round numbers the British "wires" have shown the following deficits for the fiscal years ending June 30:

Year 1918	$1,000,000
Year 1919	7,000,000
Year 1920 (estimated)	16,000,000

These are the deficits after providing for interest on the plant, and for depreciation, but without any allowance for "lost taxes."

In our last Foreign Engineering Review issue, July 30, we gave in detail the increasing deficits of the Government owned railways of France, prior to the war, as well as now.

Where, we should like to know, is any Government operating a large public utility plant at a profit sufficient to pay a bond interest rate on the plant?

Congressional Hearing on Substitutes for Wood Ties

According to press dispatches, Representative L. C. Dyer, of Missouri, introduced a resolution in the House on July 2, requesting the Interstate Commerce Commission to conduct an investigation of the substitutes for wood ties and make a report of its findings and recommendations to the House of Representatives. The commission is asked in this resolution to investigate the use of the substitute materials and also to find the relative cost of ties made of the substitute materials as compared with the cost of wood ties.

To a railroad engineer this would appear to be rather a "large order." Nevertheless, the committee on interstate and foreign commerce, to whom the resolution was referred, has already had a hearing at which various railway officials have testified as to their experience with substitute ties. It is to be hoped that no matter who conducts this investigation or testifies in the hearings, someone will soon make known the already-existing sources of information on this very important subject.

The most important and reliable data have been collected for years past by the Tie Committee of the American Railway Engineering Association. This committee, as a part of the regular annual report at the March convention, has had each year an appendix devoted solely to the subject of substitute ties, generally in the form of a progress report from various railroads having in service one or more of the different types of ties. In the committee's report for 1917 there appears as Appendix C a tabulated statement of data relating to substitute ties, no less than 42 different "makes" being given by name, together with the name of the railroad in which they are being tried, the location, date of installation, number, condition at a given date, and remarks concerning the reasons for failures and removals, if any. It has been the effort of the Tie Committee to keep the information up to date and get data on any new inventions in this line as fast as they are given any publicity by the granting of patents or otherwise.

It is surely no discredit to Mr. Dyer, who introduced the resolution for the investigation, to venture the assumption that he was unaware of the existence of the American Railway Engineering Association and of the vast amount of work which its Tie Committee has done in collecting reliable data on this vital subject. Railway engineers will welcome any additional data which this investigation may bring out, but in the interest of efficiency will deplore the covering of ground which has already been quite thoroughly worked over.

The Motion Picture Machine as an Engineering Instrument

In a letter in the Railway Age, Mr J. C. Marsh points out some of the possibilities in the engineering field for the moving picture machine. We quote from his letter as follows:

There is every reason why the moving picture machine should become a scientific instrument for the use of the civil engineering profession. Its ramifications are untold and apparently unlimited. It is surprising that some of the scientific instrument makers have not seen its possibilities and produced a machine that would meet the requirements of this field.

If an instrument were built with leveling attachments for the horizontal plane and a telescope with cross-hairs, it would seem to be what would be needed. By means of the leveling device, pictures obtained would conform to diagrams and detailed drawings. The telescope with its cross hairs would enable the operator to focus the machine carefully on the point and in the desired plane.

Such a machine would be particularly acceptable to railway engineering. With it the problem of the rail under load, that has been bothering investigators for some time, might be solved. The instrument could be set up so that the horizontal cross-hair is parallel with the top of the rail, when free from load and at a distance of ten feet from the rail so that the instrument would be prevented from receiving the vibrations from passing trains. A record of the cars and their weight would be shown in the pictures. A cross-hair immediately in front of the films and corresponding to the cross-hair in the telescope would show the actual point of the top of the rail before being loaded. As the train passed (speed to be predetermined and the reel turned to meet such a speed) the depression of the rail would be shown upon the films.

It might be possible that some calculations would be necessary, but this could be determined by experiments.

Individual films of reels, so taken, could be selected from which graphs could be made. In this manner it seems possible that accurate knowledge of the action of the rail under load at varying speeds of trains could be obtained. It would also seem possible that movements of all the rails and parts of crossings could so be obtained. These films or sets of pictures, taken in conjunction with tests of the rail under transverse and alternating stresses and with a knowledge of the elastic limit and ultimate load of the steel of the rails undergoing investigation, would apparently give the investigators a rather comprehensive knowledge of the rail under load.

Investigators of rails under load have stated that the means so far employed have not been satisfactory for many reasons. It would seem, to the writer, that the instrument or machine suggested, would be available for bridges, culverts, locomotive driving wheel counter balances and many other problems that are now perplexing railway engineers.

Concrete Coned Cattle Guard.—Cattle guards with a concrete cone surface have given excellent satisfaction on the C., B. & Q. Lines in Colorado and Wyoming. The guard consists of concrete slabs, the upper surface of which is composed of concrete cones spaced 3 in. c to c in both directions. Each cone has a base 2⅞ in. in diameter and a height of 2½ in. Each cone is reinforced by a spike placed axially, the point protruding from the top from ⅜ in. to ½ in. Eight slabs are used to a crossing. Each slab is 4 ft. long by 2 ft. 2½ in. wide. The total cost of the guard in place is about $16.27, of which $13.44 is for the 8 sections complete, and $2.83 is for the installation. The cattle guard was developed by J. H. Ellis, storekeeper of the C., B. & Q. Ry. at Hannibal, Mo.

Convention of Railway Bridge and Building Association.
The next annual convention of the American Railway Bridge and Building Association will be held Oct. 21, 22 and 23 at the Hotel Statler, Cleveland, O. The annual exhibition of the Bridge and Building Supply Men's Association will be held at the same time and place.

Methods of Moving Steam Shovels

By J. R. SHERMAN,

Division Engineer, Braden Copper Co.

Interesting information on track arrangements for the movement of steam shovels is given on page 198 of issue of "Engineering & Contracting," under date of Feb. 19, 1919. The methods employed by the writer in connection with the excavation of material for a large earth dam for the Braden Copper Co., Chile, S. A., may be of interest.

The site of the work was located about three miles from the railroad and all equipment was brought to the site over a good wagon road on which the maximum grade did not exceed 8 per cent.

Small 18-ton revolving traction shovels were brought in by taking off the boiler to reduce the weight and hauling the trucks, engine, etc., with a 12-ton traction engine. The boiler was transported to the site by horses and wagon.

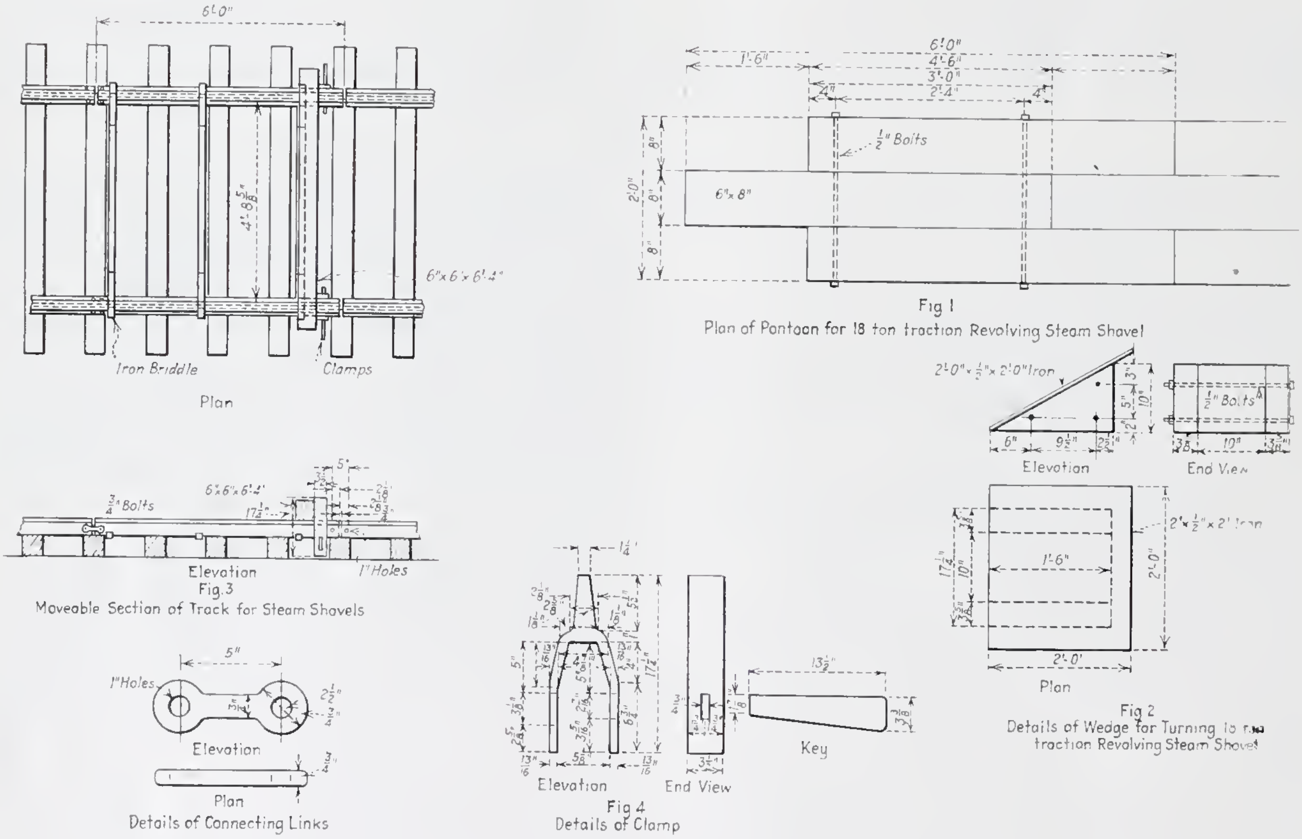

Fig 1
Plan of Pontoon for 18 ton traction Revolving Steam Shovel

Fig 2
Details of Wedge for Turning 18 ton traction Revolving Steam Shovel

Fig. 3
Moveable Section of Track for Steam Shovels

Fig 4
Details of Clamp

Track and Pontoon for Moving Traction and Railway Types of Steam Shovels.

Heavier shovels, such as 43-ton 1½-cu. yd. dipper machines, were brought in under their own power. The method employed was not new but might be outlined here. Ordinary 6-in. x 8-in. ties and 40-lb. rails (standard on Braden property) were used. The ties were carried forward by using a chain around a pile of ties and dragging with a team of horses. Each rail was also moved by one horse, using a hook fastened to the singletree and dragging the rail to approximate location where it was lifted into position by laborers.

Rail bridles or spreaders, see Fig. 3, consisting of flat iron bars with clamp on each end, were then fastened to the bottom of the rails between the ties. These serve to keep the rails upright as well as hold them to proper gage. There were four bridles used to each 30-ft. rail. Three sections of 30-ft. rail were used so that one section could be laid while other was being removed and the third one carried the shovel. The connections at joints were made by using connecting links see Fig. 3, and bolting through a hole on each end of the rails.

The moving of the small revolving traction steam shovels in the pits was handled as follows: For moving ahead 8-in. x 8-in. timbers bolted together as shown in Fig. 1 were used, one section fitting into another, thus making a continuous track. These sections were easily made and easily handled by the two pitmen. For keeping alignment or turning the shovel the steering equipment was usually not in working order so use was made of a wedge as shown in Fig. 2. For the reason that the rear axle is rigidly fastened to the base, thus making it possible to raise the rear wheels off the ground, the truck was usually reversed so that the rear end was ahead. When it was desired to move sideways one front corner of the truck was raised by thrusting the dipper down onto the ground. The wedge with its iron plate well greased was placed under the wheel. The opposite corner of the truck was then raised, thus throwing all the weight of the front end of the machine on the wheel resting on the wedge. This would then cause the wheel to slide down the iron plate on the wedge and the front end of the machine would be moved over from 12 to 15 in. This provided a very quick means of shifting the shovel sideways; in fact, a shovel could practically be turned completely around in its tracks within a short time.

For moving heavier machines in the pits, such as 43 or 45-ton railroad type, short sections of rails were used. These sections were 6 ft. long and are shown in Fig. 3. The sections are held together by means of bridles and are connected to other sections by connecting links shown on drawing. Approximately ¾ in. is allowed between the ends of the rails at the joints to facilitate making the connection. Rail clamps, Fig. 4, placed on the rails used with a tie bumper serves to keep the shovel from moving backward or forward when digging.

Convention of Ohio Engineers and Architects.—A state convention of the engineers and architects of Ohio will be held in Columbus, Ohio, on October 14 and 15 under the auspices of the Association of Ohio Technical Societies. Four principal subjects will be advanced. M. O. Leighton, chairman of the Engineers', Architects' and Constructors' Conference, will speak on "The National Department of Public Works"; Dr. F. H. Newell, of the American Association of Engineers, will speak on "Closer Co-operation in the Engineering Profession"; Charles Whiting Baker, consulting editor of the Engineering News-Record, will address the convention on the "Compensation of Engineers and Architects"; and Professor Gardner S. Williams of the University of Michigan will discuss the "Registration of Engineers and Architects."

Piece Work Versus Day Labor in Hand Excavation

By EVERETT N. BRYAN,
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In the present day of high wages and independent and inefficient labor it particularly behooves those engaged in construction work to consider carefully the comparative merits of piece work and the use of common labor on a day wage basis. The striking advantage of piece rate over day rate work is exemplified in the following cases:

A contractor engaged in state highway work in Santa Barbara county, California, in the winter of 1915-1916 moved 59,027 cu. yd. by hand work with pick and shovel and transporting in cars. The material moved was loam, adobe, and cemented gravel, with a large percentage of loose rock in places, and it all required the use of powder for loosening in order to secure best results in loading.

Of this total yardage 12,283 cu. yd. were moved by day labor in charge of a foreman generally acknowledged as above the average in this class of work. There were 9,300 cu. yd in one body, with a maximum depth of excavation of 25 ft. To load this a center drift was driven at the bottom of the excavation and as much as possible of the yardage trapped into the cars. The remaining yardage in this cut and in the smaller cuts was loaded with shovels. The average progress, including drilling, shooting, drifting, mucking, transporting, and dumping, was 6.8 cu. yd. per man day. The average progress per man day for loading effort (i. e., including labor driving the tunnel and loading cars) was 10.9 cu. yd. Common labor was paid $2.50, and the itemized unit cost per cubic yard is shown in the accompanying table.

ITEMIZED COST PER CU. YD. OF HAND EXCAVATION WITH DAY LABOR ON STATE HIGHWAY WORK.

Superintendence, engineering timekeeping	$0.038
Foremen	.039
Drilling	.017
Shooting	.049
Drifting for trap	.066
Loading cars	.170
Transporting	.090
Dumping	.020
Rough sloping	.007
General expense	.064
Total cost per cu. yd.	$0.560

The remaining 46,744 cu. yd. of the total named above were moved by nine "station gangs," i. e., gangs of partners working on a piece rate basis. They trapped some of the material into cars in center drifts at the bottom of the deeper excavations. They also trapped some material into cars beneath "lean-to" platforms against the faces of the more moderate depths of excavation, but the greater part of the material was simply shoveled into the cars. The yardage lay in shallower cuts and, all things considered, the conditions were not so favorable for rapid progress as in the case of the work handled with day labor. Yet the progress per man day, including drilling, shooting, drifting, mucking, transporting, and dumping, was 10.9 cu. yd., and the average progress per man day for loading effort only (i. e., driving tunnels, arranging traps, and loading cars) was 14.3 cu. yd. The men in some of these gangs were guaranteed $2.25 per day and for that reason this rate was used in compiling the itemized unit costs shown in an accompanying table.

ITEMIZED COST PER CU. YD. OF PIECE RATE HAND EXCAVATION ON STATE HIGHWAY WORK.

Superintendence, engineering, timekeeping	$0.023
Drilling	.008
Shooting	.040
Loading cars	.163
Transporting	.071
Dumping	.014
Rough sloping	.011
General expense	.063
Total cost per cu. yd.	$0.393

The item "General Expense," shown in these two tables of itemized costs, is one made up of numerous small items in which the expenditure could be expected to bear no relation to the daily progress. The cost of these items was estimated in preparing a bid and the unit cost so determined was not again computed until the completion of the work gave proper data for a final accurate computation. The estimated unit cost of these "General Expense" items was always added to the unit cost of daily expenditures in order to arrive at a basis of comparison of actual cost with the bid. The "General Expense" was substantially the same on both the day and piece work and was as follows for the former:

Small tools	[illegible]
Camp expense	[illegible]
Labor insurance	[illegible]
Overhead	[illegible]
Bond	[illegible]
Sprinkling	[illegible]
Rolling	[illegible]
Clearing	[illegible]
Caring for public traffic	[illegible]
Surfacing and finishing	[illegible]
Plant delivery	[illegible]
Penalty assessed by state for failure to complete contract on time	[illegible]
Miscellaneous	[illegible]
Total	[illegible]

In the winter of 1917-1918 the Waterford Irrigation District of Waterford, Calif., let to a contractor work including the excavation for 28 canal structures totaling 1,338.7 cu. yd. The minimum width of these excavations was 30 in. and the maximum width and depth never so great as to cause any inconvenience in removing the material with a single cast of the shovel. There was some hard pan in the bottoms of many of the excavations and the top dirt was usually hard so as to require constant use of the pick, but only a very little powder was used, because it was considered the use of the pick was more economical. A 2-horse slip scraper was used on a few of the larger excavations, but in no case with any real advantage, it is believed. The work was done with day labor paid by the contractor. Converting the slip scraper time into man day time of equal cost (on the assumption that the two were of about equal efficiency as regards cost and that the amount of the latter was so small as not to affect the result) and adding this to the actual time of muckers, the average progress per man day was 3.94 cu. yd.

The same contractor at same time made the excavations in a similar manner for five inverted siphons totaling 1,019 cu. yd. This material lay in larger bodies but not inconvenient for excavation by hand. One excavation only contained a little cemented gravel at the bottom which was loosened with a plow, and there was no hard pan. A slip scraper was used a very little but not with any real advantage, it is believed, nor to such an extent as to affect the result. Again converting the slip scraper time into man day time of equal cost, as above, and adding this to the actual mucker time, the average progress per man day was 6.3 cu. yd.

A complete statement of the itemized unit cost in neither of these cases is obtainable. The wages paid were $3 and $3.25 per day for common labor and data are only available showing the cost for labor, including team hire, and transportation. Transportation and labor only on the 28 smaller structures cost $0.76 per cubic yard and on the five inverted siphons cost $0.45 per cubic yard. The cost of superintendence, bond, insurance, camp, and miscellaneous smaller expenses, as powder and blacksmithing, is not known.

At the same time the Waterford Irrigation District let the excavation for three other inverted siphons to a gang of "station men." The total yardage amounted to 2,468.8 cu. yd. and of this 2,218.1 cu. yd. lay in one trench 4½ ft. wide and averaging 5½ ft. deep. The minimum depth was slightly over 4 ft. and the maximum depth was 9½ ft. The other two trenches were of smaller cross-section, the smallest one being 2.25 ft. wide and averaging 3.2 ft. in depth. The smallest trench was very hard at one end and required blasting. The middle sized trench was handled entirely without powder, and the largest trench required the use of powder throughout its entire length. The latter lay along the gutter of an unimproved street in a small town. The ground had not been disturbed for years and the top soil was so dry and hard as to make the use of powder desirable. For the greater portion of the length of this trench the bottom half was in hard pan and some of this was so hard that the hand augurs would not penetrate it and it was necessary to use hammer drills. Generally the top half of the trench was blasted and removed and then the bottom half, the men insisting this gave both less overbreak and better muck for the shovels. An average of 69/100 lb. of powder per cubic yard were used by this gang for the job and the bottom was carefully trimmed with picks to leave a smooth surface on which to lay the concrete pipe. The average progress per man day, including drilling, shooting, picking, shoveling and forge work, was 7.8 cu. yd. It was not possible to separate the mucking time from the other work because the same men changed back and forth from the one to the other many times during the day, but it is believed that approximately only two-thirds of the time went to pick and shovel work, which case the average progress per man day for muckers would be 11.7 cu. yd.

Charging the same rate of wages to this work as obtained the time on the work done by the contractor with labor on a day wage basis (i. e., $3 and $3.25 per day), the labor cost for this work would be $0.39 per cubic yard, the powder cost $0.17 per cubic yard, and tools and miscellaneous small items $0.03 per cubic yard. There was no expense for superintendence, and the district paid the labor insurance.

In each of the above described parallel cases the advantage for rapid progress lay with the work allotted to the day labor gangs, and in each case the increased efficiency of the piece rate worker over the day rate worker is amply demonstrated. The case might be multiplied not only in hand excavation but in other lines of work.

A general peculiarity of the piece rate worker which must be recognized in advance is that he will seldom bid but waits instead for the employer to name a price. If any contract is drawn up it must of necessity be a more or less informal one, as the piece rate worker neither desires nor can give a bond. He prefers to reserve the right to withdraw whenever it becomes apparent to him that things are not satisfactory.

In the case of the Swedish "station men" engaged in trench excavation described above, a part of the gang withdrew after the third day and the entire gang would have quit had not the price of $0.65 per cubic yard originally named to them been advanced. It had been necessary to start them on the most difficult work, and it was soon apparent that they were not making wages commensurate with the effort being put forth. It was impossible to convince them that conditions would so improve as to afford a fair wage, and in fact the district's engineer did not try, because the material had been worse than he had supposed. He is now convinced that the work could not be accomplished with day labor for less than $0.75 per cubic yard and he accordingly offered to advance the rate of the "station men" to that figure. They declined the offer and stated that they would not consider less than $1 per cubic yard but would be glad to proceed on a day wage basis of $3.50 per day. The engineer countered with an offer of $0.75 per cubic yard and a guarantee of not less than $3.50 per day. This offer was accepted and the results are somewhat interesting. Had the gang continued at the original rate they would have earned $3.59 per day for each day they worked. Had the district engaged them at the rate of $3.50 per day and had they worked as well for the district as they did for themselves, the work would have cost the district $0.64 per cubic yard. With the increased rate they earned an average of $4.40 per day each.

In some cases it is not practicable to attempt to compensate the entire gang on a piece rate, but it is possible to engage one or more of them to undertake the work on such a basis if the employer will pay wages to the other men and deduct the cost thereof from the total sum earned by the gang. This plan is applicable to many lines of work where the total cost is not sufficient to justify attempting to contract it out in the usual way. The work requires less watching than when done by day labor and is generally accomplished with greater satisfaction to both employer and employe.

A Definition of the Construction Industry.—The National Federation of Construction Industries in one of its recent news letters gives the following definition of the construction industry:

> The construction industry embraces the construction of residences, warehouses, factory, office and other buildings, roads, streets, railroads, bridges, docks, tunnels, dams, water works, sewers and other public works; dredging, irrigation, wrecking and remodeling; the production, manufacture and distribution of materials, equipment and machinery entering into or used in connection with construction; manufactures, contractors, sub-contractors, engineers, architects, building and highway commissioners, realty and mortgage bankers, insurance companies, real estate developers, building and loan associations, and other professional financial, commercial and industrial interests connected with construction or real estate development.

North Carolina Engineering Society to Affiliate with A. A. E.—The North Carolina Society of Civil Engineers has voted to proceed with consolidation with the American Association of Engineers, and to carry out the affiliation as soon as the committee appointed to conduct the negotiations has completed its work. The president of the society is Dr. W. C. Riddick, president of North Carolina State College.

Building Up a Worn Dredge Pump With the Oxy-Acetylene Process

The type of centrifugal pump used by dredging contractors and mining operators for such purposes as dredging silt, sand, mud and gravel from the bottoms of channels and for mining soft ore by the hydraulic mining system, is subject to excessive wear due to the constant abrasion of the sand and gravel against the inner walls of the pump chamber.

Such a sand sucker chamber that had become badly scored through use was recently restored to practically its original condition by the Chicago job welding department of the Oxweld Acetylene Co., by means of the oxy-acetylene process.

The pump chamber of the sand sucker was 14 ft. in outside diameter, and consisted of two massive steel castings having a total weight of 7 tons. The abrasion had been so severe it was necessary to rebuild both side walls of the pump chamber for a distance of 8 in. from the inner circumference. The thickness of the added metal varied from 1½ to 2½ in. In addition, a new section approximately 14 by 18 in. in area had to be welded into the throat of the casting. The latter was approximately 3½ in. in thickness.

Building Up Worn Surfaces of Sand Sucker, Depositing 1,264 Lb. of High Carbon Steel With Aid of Oxweld Oxy-Acetylene Blowpipes.

In order to insure holding the two halves of the chamber in alignment during preheating and welding they were bolted together and the heavy outer reinforced sections of the castings were not heated, as this would have produced internal strains, either breaking the castings or shearing the bolts that held them together. Preheating by means of charcoal was applied locally for a distance of about 14 in. in from the edges of the flanges, each preheat extending for a distance of 3 ft. around the inner circumference.

The total weight of steel added to the castings by welding amounted to 1,264 lb. The operators, each using an Oxweld blowpipe fitted with No. 15 welding head, worked in pairs. As the heat in the small enclosure where the men worked was intense, it was necessary to hold several welders in reserve and to work on the relay plan, each welding shift extending for a period of 20 minutes. Six days were required to complete the building-up work.

As the built-up surface will be subjected to the same abrasive action of sand and gravel, high carbon steel welding rods were used for the purpose of building up, thereby giving an extremely hard surface, in fact, one that it was impossible to cut with a file, after cooling.

Steam Shovel Safety Devices.—Many mining companies operating on the Mesabi Iron Range, Minnesota, have adopted standard safety devices for their equipment. Steam shovels, for instance, have guard rails extending along the running boards on either side, as well as along the ladders on the boom. Running gears are substantially protected, and where possible, the moving parts are covered. A short cable is extended from the top of the A-frame to the top of the boom and serves to prevent the dropping of the boom in case the "hog rods" should break.

Definition of Terms in Valuation Work

In a report to be presented at the October meeting of the American Electric Ry. Association the committee on valuation has submitted its recommendations for the items to be considered in estimating "fair value" of a property for "rate mixing." It is believed that these items, together with the definition of terms, are of enough general interest to quote verbatim from this report.

Items to Be Considered in Estimating Fair Value for Rate Making.

(a) Promotion expense.
(b) Organization expense
(c) Brokerage.
(d) Construction costs. (Based upon actual property inventory at prices as of the day and date of inventory.
(e) Overhead direct charges not included in (d)................
  - Engineering and superintendence.
  - Storeroom expenses, cost of handling materials, clerks, general office help, contingencies.
  - Contractors' profit.
  - Carrying charges during construction.
  - Taxes during construction.
  - Insurance during construction.

(f) Going concern..........
  - (1) Cost of consolidation
  - (2) Superseded property
  - (3) Created value
  - (4) Development costs.

(g) Working capital.

Definition of Terms.

Promotion Expense.—The initial work necessary to start a public utility enterprise requires the time, effort and work of capable men to plan the proposed service, to show its public necessity, to estimate the possible business and prepare construction costs, gross receipts and operation expense statements, prepare the preliminary work necessary to procure franchises, etc. This work is a service of value to the public and represents a money value properly chargeable to capital account.

Organization Expense.—An efficient organization must be carried during the formation and construction period consisting of legal, financial and business experience and ability to arrange for and carry on the details of company organization and the creation and construction of the property. This expenditure is a proper charge to capital account.

Brokerage.—The money necessary to create the properties must be arranged for through sales of stock and bonds, and bankers or brokers are generally engaged to place the securities and collect the money as required. This means,

The payment of commissions
Preparation of mortgage
Service of registrar, corporate and individual
Service of trustees
Cost of certification
Revenue stamps
Cost of recording mortgage
Public service commission costs for approval
Advertising,

and other expenses, and this brokerage cost should be included in any investment estimate for rate making.

Construction Costs.—A detailed inventory and classification of the existing physical property forms the basis of all "Cost to Reproduce New Valuations" to which should be applied unit prices and costs for values as of the date of inventory. The value based upon present day prices is then in accord with current rates of wages, current cost of material and the current value of a dollar and is economically sound. To the "bare bones" inventory at unit prices must be added the direct and indirect overhead charges not included in the unit prices for rails, other construction materials, labor costs, etc., all as enumerated.

Overhead Charges.—The items of direct overhead charges enumerated should require no further explanation. The purchasing of the materials, their transportation, sub-delivery, accounting, inspection, etc., require supervision and direction and the effort of large forces of storeroom and general office help, inspectors and checkers, the cost of which is not included in unit prices.

The general and detail design of all parts of the property require the work of engineers and architects and their assistants to make drawings, bills of material, working specifications and prepare purchase contracts, the general direction of the work in the field, the making of estimates of cost, progress estimates, partial payment estimates for all contracts and the general supervision and progress of all parts of the construction, the cost of which could not be included in unit prices.

During the progress of the work, cash must be provided to pay the current labor, material costs and partial payment contract estimates and interest must be paid upon the capital as it is invested during the period of construction and before the property can earn a return. The same is true of taxes, and insurance, including fire and accident. Interest, taxes and insurance during the construction period are a part of construction costs and should be a capital charge.

In the building and erection of a large property many contracts are entered into for specific kinds of materials in quantities, special machinery, track work, buildings, etc., and the item of contractors' profit is one of the construction costs that must be included in "fair value" for rate making.

The item of contingencies is an important one in any cost estimate whether it be to furnish advance information to financiers and promoters, or in connection with any large public improvement, or our own problem "the establishment of a reasonable and just investment value" and covers the uncertainties, omissions, additions, extras, attendant upon any construction job, large or small, and among many others, includes the following unforeseen but ever present items of delay, removal of obstructions, the appearance of conglomerate, hard pan, or solid rock in excavations where earth had been estimated, slides in open cuts, the removal and restorations of water pipes, gas pipes, electric wires and other underground improvements, under-pinning of buildings, etc. The item of the removal of underground obstructions alone often equals 25 per cent of the total construction costs in subway work, and quoting from the paper on "Overhead Charges" presented by Mr. Philip J. Kealy in the 1916 report of this committee, we find the following statement, under the heading "Incidentals or Contingencies."

"During a recent hearing before the Valuation Committee of the Interstate Commerce Commission, Mr. Holbrook, Chief Engineer of the Union Pacific R. R., stated that after the completion of the Lucin cutoff across Great Salt Lake, he had his engineering staff estimate the cost of the work already completed and the highest estimate was 40 per cent under the actual cost."

This item of contingencies is a real item of cost in every job and ranges from 10 to 50 per cent of the total cost and in some hazardous undertakings such as under-water tunnel or foundation work, the actual cost is sometimes many times greater than the "bare bones" bill of material contract-specification estimate of costs.

Going Concern (Health of the Property).—Represents the value that exists in a completed, matured, successfully operated property and embraces the items of "readiness to serve" a "built up successful business," etc., as compared with a new property in the course of construction, or the immature condition usually prevalent at the beginning of its operation and other development costs including an amount equal to the deficiency of net earnings below a fair return upon the fair investment due solely to the time and expenditure reasonably necessary and proper to the development of the business and property to its present stage and not comprised in the valuation of the physical property.

Cost of Consolidation.—In the past, competing companies were granted franchises in the same community and duplication of operating organizations and other expenses resulted and the service to the public was less efficient and more expensive. Under one management the public has benefited by a lower average fare, the more direct routing of cars and an extension of service for a single fare. Much time, effort and expense is usually involved in bringing about a consolidation. This development expense is of value to the public and its cost is a proper charge to capital account.

Superseded Property.—A public utility property is entitled to repayment for all of its property consumed in the service of the public.

The ordinary replacement or renewal of property actually worn out in the service is charged to operating expense and is therefore amortized out of earnings. It is only when large replacements of property are made necessary by extraordinary changes of motive power such as from horse car to cable, or electricity, or both, or wreckage due to violent storms, earthquakes or other unusually destructive calamities, or when due to improvements in the art, the general type of car, or other property in service is replaced in large quantities that it becomes impracticable to immediately amortize out of earnings and new capital must be used, and this new capital should be included in "fair value" upon which to base a return until such time as it has been amortized.

Created Value.—This item covers an important element of value that may properly be a part of "Going Concern Value" and represents the value due to the utility having been brought into existence and becoming a live and a vital part of the community. Having pioneered the growth of the city or commonwealth and enhanced the value of both private and public property, the utility itself should be justly credited with part at least of the value it so created.

Working Capital.—Every business should have a "Cash reserve" or "Working capital" to "cushion" the rise and fall between income and expenditures, to carry materials and supplies account, and especially to fortify it against any reasonable financial emergency that may arise. An adequate allowance for this item should be included in capitalization.

An Ingenious Track Ditching Machine

The Northwestern Pacific Ry., in Northern California has a part of its line located in Eel River canyon in which considerable trouble is experienced due to the instability of the glacial material of which the sides of the canyon are composed. The trouble is especially bad in seasons of heavy rainfall common in that region, during which the ditches at the side of the track fill up with loose material. The Railway Maintenance Engineer describes how Mr. J. G. Butler, foreman of work equipment, has ingeniously solved the problem of cheaply and efficiently cleaning out these ditches.

The road has as a part of its equipment two 12-ton locomotive cranes, and it occurred to Mr. Butler that these cranes could be fitted up to clean these ditches with the help of a drag-line bucket. His idea was essentially to fasten a boom to the body of the crane so that the bucket could be hauled along the ditch parallel to the track. The equipment was first prepared for this use about two years ago and has been in almost constant service ever since, so that there has been ample opportunity to demonstrate its value.

A 75-lb. rail about 20 ft. long was attached to each end of the car body, and this rail is used to regulate the distance of the ditch from the track. A 1-in. cable is attached to the rear of the car and runs through a hole at the outer end of this rail to a hook on the bale of the drag bucket; a monkey line from the crane also runs to the bale of the drag bucket and is used to hold the bale in position.

After the drag bucket has been placed in this position the crane moves backward until the bucket has been filled. If the ditching is being done in a side cut the crane boom is swung over to the clear side where the drag bucket is in position to be dumped by the holding line.

In the case of a through cut the crane may be run to the end of the cut before the drag bucket is dumped, or the bucket may be emptied into an air dump car and the material disposed of later.

On the Northwestern Pacific all cranes are self-propelling and equipped with air pumps and reservoirs so that dump cars may be handled without other assistance. Where material is encountered in ditches too hard to be handled by the drag bucket, a rooter plow is attached to the bucket and dragged through the ditches to put the material into condition to be handled by the bucket. The ditching is done with a regular crane crew, consisting of a crane engineer, fireman and one helper. With this crew in side hill work; that is, where there is a ditch on only one side of the track, the average progress is about one track mile per day. Patents upon this device are pending.

Higher Salaries for Technical Employes of New York City.—The Union of Technical Men has issued an appeal to the municipal officials of New York City asking for salary increases. An increase of $500 per year for all technical men employed by the city is asked. This would affect about 2,500 men, of which about 2,370 are new receiving less than $3,000 per year.

Magnetic Surveys of Rail

According to a paper presented at the annual meeting of the American Society for Testing Materials last June by Dr. P. H. Dudley, magnetic surveys furnish information impossible to obtain by any other means without destruction of the material; at the same time it is possible to study the fatigue of metal. The matter following is abstracted from Dr. Dudley's paper.

The first equipment for surveys of rails was developed at the U. S. Bureau of Standards under the direction of Dr. C. W. Burrows. The apparatus designed by Dr. Dudley with the assistance of H. A. Currie and his assistant, H. C. McMillan, of the electrical department of the New York Central Lines for the present investigation embodies all of the essential and principal details of the Bureau of Standard's equipment except for a few minor changes which were necessary under the circumstances in which our tests were conducted.

"Fatigue Fractures of Metal."—There have developed several cases of induced interior transverse fissures in rail heads under service conditions in the present decade of railroad operations. These have been improperly designated "transverse fissures," a term which does not express their location or origin in the interior metal of the rail head. The checked nuclei are invisible to the inspectors of the rails at the mills and to the section men and supervisors in the track. It needs magnetic vision to find them in the rail heads as fabricated. The Division of Safety of the Interstate Commerce Commission, from its investigations, classifies them as "fatigue fractures of metal" due to the wheel loads, and holds that all rails are subject to them. The remedy it proposes is to reduce the wheel loads. This recommendation was made before collecting the service records for rails of different methods of manufacture to see whether or not all were affected alike. The railroad officials, from their records of the service of various rolling of rails, find that those rolled from reheated blooms are nearly free from interior transverse fissures. They find that rails of the same section when rolled direct from the ingots, laid on portions of the same roadbed, and under the same wheel loads, develop a greater number of interior transverse fissures.

Eight railroad companies under heavy traffic reported from their service records 322,593 tons of rails from reheated blooms in which only 59 induced interior transverse fissures developed in the rail heads. Their records also included 559,644 tons of rails by direct rolling in which 1,054 induced interior transverse fissures developed, an increase of 900 per cent over those in rails from the reheated blooms. These rails were rolled in 1909 to 1915 inclusive, while the records of fissures were to October, 1918.

Such a difference in the service of rails under practically the same wheel loads is evidence to railroad officials that there is some inhomogeneity of the physical properties in the metal of the interior of the rail heads—particularly those rolled direct—which induce the interior transverse fissures, compared with interior metal from those rail heads which do not develop such fissures in similar service.

The paramount question with railroad officials is "safety first," and hundreds of the failed rail heads have been tested under the drop for brittleness; also tension tests have been made of the metal of the interior of the head which show a loss of ductility of the metal compared with the enclosing envelope of exterior metal. Delayed transformations have been found by heating and cooling curves; and cores of abnormal metal first on one side of the center of the head which changed to the opposite side of the head in a few inches of length. Well-developed polyhedral crystals have been found as the nuclei of interior transverse fissures which indicate that a germinative temperature existed a sufficient length of time for their development; 132 rails were cut in small pieces, and well-developed crystals were found in 22.

These facts were found only after destruction of the rails. Similar tests could be made only from pieces cut from the top or bottom of the rail crops which do not go to the hot beds to cool, and therefore are not representative of the occasional rail on the hot beds which fails in the track. It is this feature of magnetic analysis without destruction of the section which offers the probability of detecting and eliminating the occasional rail which was rolled direct, before it leaves the mill or is put in the track.

Intergranular Fissures.—The more predominant type of induced interior transverse fissures is classified under the name of "intergranular." The fracture of the rail is made up of three separate and distinct parts, namely:

1. The nucleus, or central intergranular area.
2. The lustrous detail development surrounding the nucleus.
3. Fracture of the balance of the rail which occurs quickly after the fissure has developed sufficiently to impair the strength and integrity of the rail section. Each distinct fracture occurs only in widely separated periods of time

The lustrous detail fracture through the grains is the progressive growth or development from the nucleus, and is now universally recognized as being due to the bending action of the rail under the passage of many thousands of wheels. The problem is therefore reduced to the study of the character and cause, in rails which are rolled direct for the fracture of the nucleus. Except in rare cases of this type, no interior detail fractures have developed without having started from the characteristic intergranular nucleus.

Numerous tests have shown that the essential characteristics of the metal in the vicinity of the nucleus are low tensile strength, brittleness, and a practical absence of ductility. The character and appearance of the nucleus furnish positive evidence of its method of failure. Examination discloses that fracture of this intergranular area occurs suddenly, the whole area which is sometimes as large as $\frac{3}{8}$ in. in diameter failing as a unit. This is produced by the application of a concentrated overload of sufficient magnitude to cause sudden fracture.

Effects of Overloads at the Mill.—To explain how the overloads at the mill occur, the hot 105-lb. rails are sawed 33 ft. 6¾ in. to shrink to 33 ft., then cambered—the head curved around the base—and run to the hot beds, where, as they cool, recalescence of the base occurs, which expands it around the head. Then the head undergoes recalescence and expands around the base more than the original camber. When the rails cool to atmospheric temperature, they are expected to be nearly straight. This is never the case and the rails must be gagged to make the surface and line suitable to be laid in the track. The operation under the straightening press consists of applying the gag on the rail to produce permanent sets where needed at intervals along its length, but in so doing harmful impact stresses of an intensity of 100,000 lb. per square inch and over are frequently imparted to the metal in the interior of the rail head. The severity and magnitude of overloading during gagging depends upon the physical condition of the metal in the interior of the head and the curvature of each rail as received for straightening. Metal with a tensile strength below the delivered impact stress in the rail head is therefore liable to be fractured. This weak interior metal when fractured provides the checked nucleus from which the induced interior transverse fissure subsequently develops in service. Overloading during straightening is sometimes so severe that the rail section is completely fractured.

Numerous efforts have been made to eliminate the destructive effect of gagging. It is possible to effect a reduction in the amount of pressure transmitted in the rail by increasing the span of the supports of the press. Thus, 50,000 lb. less pressure is required to straighten 6-in. 105-lb. rails on supports of 60-in. span than on supports of 42-in. span, which is the present mill standard. The solution of the problem in the mill then consists of two parts: First, the avoidance of brittleness of the metal, by proper chemical composition and manufacture. Second, the reduction of the destructive and injurious effect of gagging, which now has the co-operation of several steel plants, by widening the supports to 60-in. for stiff sections.

Investigations are being made of the rails from reheated blooms which develop in the track induced interior transverse fissures. The results indicate that the final temperature of the bar as rolled is too low to accomplish what reheating the blooms usually does to the interior of the metal in the rail head. This may be due to some delay in rolling the bloom in one or more passes before the finishing. There is one mill which reheats the blooms concerning which we have yet to hear of a single interior transverse fissure in its large output, and another mill which has only one against its output.

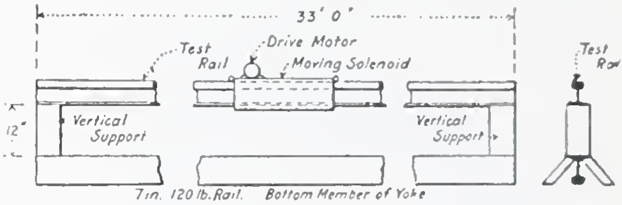
The statement of fact regarding the freedom from interior transverse fissures of rails rolled from reheated blooms does not of course explain how reheating improves the interior metal of the rail head. The necessity of prompt action, however, requires that we first heed the facts and act, then investigate the reasons at more leisure. The inability during the past year to secure rails rolled direct from one ingot and from reheated blooms from the next ingot of the same heat has for the time being prevented comparative magnetic investigation of the interior metal in the rail heads by these two methods of manufacture.

Equipment for Magnetic Survey.—The sketch illustrates the general set-up of the magnetic testing equipment. It consists of a bottom supporting member, which is a 33-ft. rail turned base up; two sections of rail 12-in. high which act as vertical supports; and the test rail which forms the top and closing member of the yoke. The energizing or magnetizing solenoid travels along the test rail at a uniform rate and is driven by a motor mounted above, and geared direct to the brass drive roller. Search coils are concealed within the solenoid shell for the detection of variations in the permeability of both the rail head and base, and are separately connected to the galvanometer circuit.

The following are some data of the equipment and its characteristics:

Dimensions of solenoid	6 by 6⅝ by 24 in. long
Magnetizing force	10,000 ampere turns
Voltage	60 volts.
Current	4.72 amperes.
Total number of turns	2,120.
Length of winding	1,840 ft.
Size of wire	No. 13 D. C. C.
Batteries	Willard, 5 crates of 6 cells each
Drive motor	Eck, 1-6 h.p.
Galvanometer	Leeds & Northrup—Type R, No. 2500
Search coil	50 turns of No. 30 D. C. C.

Permanent records of the surveys are obtained by reflecting a beam of light from the galvanometer mirror into a special camera box which contains a moving strip of film.



Arrangement of Apparatus for Magnetic Survey of Rails.

The conditions under which all surveys are made are maintained standard, so that the records are comparative one with another.

All tests and surveys have been made in the electric shops of the New York Central Railroad at Harmon, N. Y. No tests have been made at the steel plants or out on the tracks.

Results of Magnetic Surveys. The reliability, accuracy and consistency of magnetic surveys on steel rails have been checked by duplicate curves. Over 1,000 observations have been made, together with 217 permanent records on 60 new and 56 failed rails. Surveys have been successfully conducted on sections of 80, 90, 100 and 105 lb. in weight, and in lengths of from 8 to 33 ft., necessitating only one slight change in the standard equipment for all sections. The expense involved in making the surveys is small, the time required to test each rail is moderate, and the equipment requires a minimum amount of space and can be quickly dismantled and moved. We have made numerous complete surveys on rails in 25 minutes, one-half of the time being required for handling the rail on and off the vertical supports. This time can be further reduced when changes in methods of handling and making surveys are instituted.

The permanent records obtained are complete histories of each rail, and furnish information which is not secured by any other method of testing. No machine work or special preparation of the rails to be tested is necessary and furthermore the characteristics and quality of the material are obtained without destruction of the rail. The superiority of magnetism testing in this respect is marked when compared with tension testing. The latter requires time and expense for preparation of specimens, destruction of the material tested, and at best furnishes information on only about 4 in. in the length of the rail.

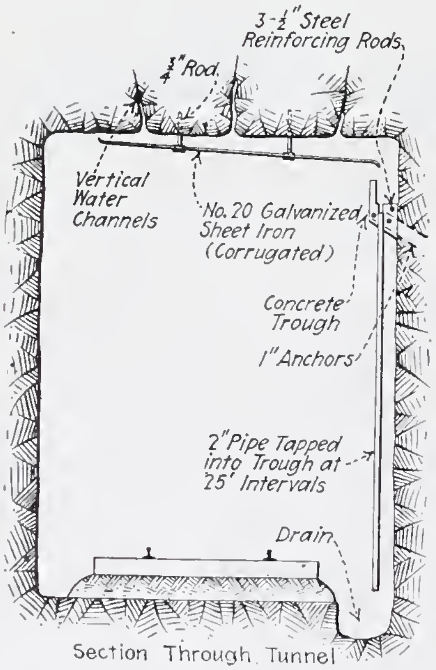
Possibilities of the Magnetic Survey. Magnetic surveys and analyses furnish a fund of information which cannot be secured by any other method of testing. The fact that the materials can be tested without destruction is of prime importance. It is this feature of magnetic analysis which makes it possible to find in advance those rails which, after injury under the straightening press, would develop in service into a complete interior transverse fissure.

It would seem from what has been accomplished already that other railroad companies are warranted in using similar apparatus to make magnetic surveys of their sections of rails which are rolled direct. Such surveys for the present can best be made by the railroad companies. Ample room and time are required to determine the brittleness of ductility of the metal in the interior of the heads of a number of rails of one section. A certain amount of ductility is necessary to meet the requirements of traffic under the climatic conditions of the location of the line.

Railroad service requires so many grades of steel with a wide range of physical properties in axles, crank pins, connecting, parallel and piston rods, rails, tires and wheels, that there are several opportunities to develop magnetic apparatus for testing them without destruction. It will also be possible at the same time to study the fatigue of metals and the restoration of their normal physical properties. To mention one example of restoration, several hundred axles which had been used for five years were immersed in an oil bath and raised to 600° F. for 6 to 8 hours, and they have since rendered five years' additional service without a failure.

Water Drain for Tunnel Roof

In driving a drift to be used as a main haulageway at a mine in Southeast Missouri, the workmen cut several water bearing strata that continued to flow after the drift was completed. As a means of preventing the leakage of water from the roof, the system of collecting and draining, shown in the sketch, was satisfactorily installed at a moderate cost and with little consumption of time, states Mr. Roy H. Poston in the Engineering and Mining Journal.


3-½" Steel Reinforcing Rods
¾" Rod
Vertical Water Channels
No. 20 Galvanized Sheet Iron (Corrugated)
Concrete Trough
1" Anchors
2" Pipe Tapped into Trough at 25' Intervals
Drain
Section Through Tunnel

Method of Handling Water From Tunnel Roof.

As the continuous dampness made the preservation of wooden construction difficult, concrete installation was decided upon. Considering that this latter type imposes practically no cost for maintenance, and that the wet part of the tunnel was short, the additional initial expense was considered justifiable and a permanent installation was provided.

Shower Baths for Mine Mules.—As a means for removing dirt and perspiration from mine mules the U. S. Steel Corporation has installed shower baths at some of its properties. The bath consists of a tubular framework having at the top three perforated nozzles sufficient to spray the entire body of the animal.

Classification of Technical Railway Employees

A classification of technical employes of railways in the Northwestern region has been submitted to the federal managers in that region by R. H. Aishton, regional director. The classification was prepared by a committee consisting of H. E. Stevens, chief engineer, Northern Pacific Ry.; C. F. Lowth, chief engineer, Chicago, Milwaukee & St. Paul Ry., and A. Mintzheimer, chief engineer, Elgin, Joliet & Eastern R. R. The schedule, which covers only positions below the grades of assistant engineer and chief draftsman, follows:

Draftsmen, Class 1, $200-225: On general or special duty, requiring special knowledge, training and experience, and a special degree of initiative and originality, thoroughly competent, engaged regularly in the design and general direction of the design of large and difficult work on yards and terminals, track details, etc., or steel, concrete and timber bridges and structures, or special buildings, etc., or locomotives, cars, special machinery, mechanical and electrical power plants, etc.

Draftsmen, Class 2, $175-190: On general or special duty, requiring special knowledge or training and experience and the use of initiative and originality. Engaged in the general designing and the direction of detailing of plans of yards and terminals, track details, etc., or steel, concrete, or timber bridges and structures, or special buildings, power plants, etc., or locomotives, cars, special machinery, or signals and signal apparatus, or land, right-of-way and valuation maps and profiles from field notes and records.

Draftsmen, Class 3, $150-165: On general or subordinate duty, requiring special knowledge or training, experience and initiative, generally engaged in the designing and detailing of work in accordance with standard practices, and the direction of work of a minor character on right-of-way maps, mileage records, or steel, concrete and timber bridges and structures, or locomotives, cars, special machinery, mechanical and electrical power plants, or signals and signal apparatus, or land, right-of-way and valuation maps and profiles from field notes and records.

Draftsmen, Class 4, $125-140: On subordinate duty requiring a certain amount of knowledge, training or experience, and engaged generally in detailing, compiling and recording general engineering plans, land and right-of-way maps, or valuation maps and profiles, or records of bridges, buildings, locomotives, cars or signals.

Tracers, $100-120: On subordinate duty requiring a certain amount of experience or knowledge of drafting. Capable of doing neat, accurate and rapid work.

Engineering Inspectors, Class 1, $175-185: On general or special duty requiring special knowledge, training and experience and the use of initiative. Capable of directing and supervising the inspection of extensive engineering construction and all classes of construction materials.

Engineering Inspectors, Class 2, $150-165: On general duty requiring special knowledge or training and experience and the use of initiative. Capable of supervising the inspection of average engineering construction and materials.

Engineering Inspectors, Class 3, $125-140: On subordinate duty requiring a certain amount of knowledge or training and experience. Capable of inspecting minor construction work and materials.

Instrumentmen, Class 1, $180-200: On general or special duty, requiring special knowledge, training and experience and the use of initiative. Capable of directing a field party, and responsible for technical field work of a complicated and difficult nature, and platting the field notes and data.

Instrumentmen, Class 2, $150-170: On general or special duty, requiring special knowledge, training and experience and the use of initiative. Capable of directing a field party, making personal investigation of ordinary field work, and platting the field notes and data.

Rodmen, Class 1, $120-130: On subordinate duty with knowledge, training and experience. Capable of doing ordinary field work, without supervision or more difficult field work with supervision, and platting the field notes and data.

Rodmen, Class 2, $100-115: On subordinate duty with a certain amount of knowledge of field work, but not required to use transit or level.

Chainmen or Trainmen, $90-100: On subordinate duty, preferably with a certain amount of knowledge or experience in field work.

Surveying and Mapping from Airplanes

In an address before the Second Pan-American Aeronautic Convention, at Atlantic City, in May of this year, Col. E. Lester Jones, Superintendent of the U. S. Coast and Geodetic Survey, gives at some length his ideas concerning the use of airplanes in surveying and mapping. The following is an abstract of his address:

War planes were made for various purposes which need not be enumerated, but the most important thing done from the aeroplane was photographing the enemies' lines and thereby discovering the positions of the batteries, ammunition dumps, the truck systems and other military facts and features.

The same methods, with some modifications, are now being considered in connection with the mapping of extensive areas by the map-making organizations of the country. In fact, some work has already been done and experiments are being carried on which promise excellent results.

Classes of Maps Needed in This Country.—There are several types of high grade maps needed in the country. One must be made along the coasts to show the location of the actual shore line and the character of the ground immediately back of the coast in order that the navigator may be able to locate himself from topographic features along the shore, should he be driven off his course during a storm. In addition the depths of the water and all obstructions to navigation must be indicated on this map or chart, the elevation and shape of the ground on islands and just back of the coast must be shown on the map by contours.

A second class consists of maps on which the features other than elevations and contours are shown in their correct horizontal positions. This type of map would be practically the same as the third type where the area covered is very level. Such an area would be the coastal plain of Louisiana.

The third class covers maps of the interior or of large islands on which all features, cultural and natural, are located in their proper horizontal position and contours are shown to give the elevations of the ground and the shape of the hills, ridges, valleys, etc. This map would be used by engineers in laying out railroads and highways, and in conducting various classes of engineering work.

In any event there must be within the area to be surveyed, if it is a large one, a number of control stations. These control stations consist of triangulation stations placed on the highest parts of the ground or traverse stations which may be along the roads, which are accurately located in latitude and longitude and which are accurately and substantially marked with concrete or rock in order that they may be recovered and identified by any surveyors or engineers who wish to use them.

There are now many thousands of such stations in the United States, established principally by the Coast and Geodetic Survey, available for the fundamental control of surveys and maps. From the stations established by that Bureau control of the same or of a lower grade of accuracy may be extended in any direction for the immediate control of topographic maps.

It is readily seen that without the fundamental control, which extends over the whole area of the United States, there would be great confusion. If the control in any one state is not properly co-ordinated and correlated with that of any other state near it, the result will be that when different topographic surveys and maps are joined there will be overlaps, gaps and offsets which cause no end of trouble and confusion to the cartographer and map maker. When there is a single system of control for the whole country we avoid this unfortunate condition.

Only 40 Per Cent of United States Mapped.—There is today only about 40 per cent of the 3,000,000 square miles of the United States mapped both as to horizontal positions of the features and the elevations by contours of hills, ridges, valleys, etc. These are the maps of class three, mentioned previously. Some of the 40 per cent of the surveyed area will have to be resurveyed because the original work was done many years ago when methods were not as refined as they are today and the demands of map users were not as exacting as they are at present. It is safe to say that not over 30 to 35 per cent or one third of the whole country is adequately mapped.

The question is, what shall be done with the other 60 per cent? This is a question that is puzzling map makers constantly and no ready solution is at hand provided we insist on having a map of the whole area within a few years.

Should Not Expect Too Much from Aeroplane Mapping.—It is possible that here may be a valuable field for the aeroplane. It is not believed that the aeroplane unsupported by other surveying can give the final accuracy required in original surveys. But by its means can be made a map that will be much better than the maps which may be in existence today in the areas which have not been topographically mapped. In order that the remaining 60 per cent of the country might be mapped by aeroplane it would be necessary to have a great amount of triangulation and traverse run with a view to furnishing the horizontal control for the photographs to be made by the aeroplane. With this control, it would be possible to fit the photographs on the map into their proper positions.

It is not possible to run many miles with aeroplane photographs and expect to have a very high degree of accuracy in the resulting maps, and here I wish to give a word of caution to the advocates of aeroplane mapping, that everything cannot be expected of aeroplane mapping. The development of this science will undoubtedly be rather slow for a few years. After it has been developed methods must, of course, be thoroughly tested before they can be adopted. It is well that this is so for otherwise haste might cause mistakes which would discredit the method to such an extent that it would take years to recover.

Aeroplane Photography as Supplement to Usual Methods of Hydrographic Surveying.—The coast line of the United States has been mapped, but the currents and waves of the oceans cause many large changes in the shore line. In the case of Fire Island entrance, Long Island, New York this was changed in position about 4 miles in 50 years. The changes are so rapid that frequent resurveys of the coast must be made to furnish exact and reliable information to the navigator. It is also necessary to revise the area just back from the coast, for roads are frequently changed in position or abandoned, new ones are established, houses are built or burned, villages spring up, woods are removed or grow over what were vacant fields at the time the map was made and all of these changes should be shown for the use of the mariner. The question arises as to how such revision shall be made.

From the experience of the engineers of the Coast and Geodetic Survey the revision of an area that does not need contouring is almost as expensive and takes almost as much time as the original survey, for it is necessary to make a test of the position of each feature. It is here that the aeroplane will be of the greatest service, for if a portion of the shore line should be inspected with a view to learning whether or not the map of it should be revised, we could have a series of photographs made by an aeroplane along the coast, and a comparison of the photographs with the original map would enable one to locate very definitely each area within which are new features or where old ones have changed. It is believed that in most cases the details on an airplane photograph could be placed on the map from the photograph with all of the accuracy that is needed in the topography shown on the coast charts.

It is a debatable question as to whether the aeroplane photograph made over a water area will show any outline of dangers to navigation when the plates are developed. If they are shown, there is a vast field for the aeroplane in making photographs over water areas where it is known that many obstructions exist. With the usual surveying methods, it is difficult at times to locate every obstruction. One or more on any chart might be missed. The fact has been proved a number of times in a most disastrous way by vessels running on uncharted rocks both along our eastern and our western coasts and especially in Alaska.

The Coast and Geodetic Survey is now making wire drag surveys of all doubtful areas along the coast but it will be many years before the bureau can assure the navigating public that all obstructions have been found and accurately charted.

It may be possible that an aeroplane photograph will indicate submerged rocks or other dangers that are close to the surface of the water. It would be a question of differences in shade in the photograph. If such a detection of danger can be made then one must be very cautious to make the photographs only on perfectly clear days. Otherwise, the cloud passing over makes its shadow on the water which might show on the photograph and cause uncertainty as to whether the spot is a cloud or an actual obstruction.

There are many hundreds of square miles of area along the coast that consist of salt marshes with many streams of little or no importance but which should be shown in their proper relation to other topographic features. These marshes can be photographed from aeroplanes and the streams running through them would probably show in such a way that they could be fitted into the map from the photograph. Here might be a large saving of time for the surveyor in the field.

There are other cases where there are extensive mud flats, when the tide is low, as in Jamaica Bay, New York. To survey the outline for these flats is rather laborious, with the usual instrumental methods, but it is believed that it might be possible to photograph them from an aeroplane and have the results placed on charts. It will undoubtedly be possible to get these located on the charts from aeroplane photographs with all the accuracy that is necessary for the navigator.

In making photographs from the water, for the purpose of discovering obstructions to navigation at low tide it will be necessary to have some means to properly locate photographic features on the chart. This probably can be done by anchoring two or three small boats within the area of the photograph and locating them with relation to triangulation stations. The location could be done in the usual way in which the sounding boat is today given its position, that is by taking two sextant angles simultaneously from a boat to three control points. It can readily be seen that if two or three accurately located boats are clearly shown on the aeroplane photograph, it will be possible to place the topographic details on the map in their proper positions.

I do not wish to convey the idea that the aeroplane photography will supersede the usual methods of hydrographic surveying, but it would supplement those methods by making it possible to discover channels running through mud flats, also coral heads, shoals, and other obstructions which might be close to the surface of the water and which may be missed by the usual methods of conducting hydrographic surveying.

There has been a rather positive statement made above that the aeroplane can be used to advantage in the work of the Coast and Geodetic Survey. This is undoubtedly true but only time and the development of the methods can show just how much the aeroplane can be used by this Bureau.

Use of Aeroplane in Surveys of Interior of Country.—We now come to the third class of maps and that is a subject on which I hesitate to express an opinion. That is the mapping of the interior of the country. This work is undertaken by the U. S. Geological Survey, supplemented to a certain extent by the Corps of Engineers, U. S. Army. The Coast and Geodetic Survey co-operates with those two organizations to the extent of furnishing the fundamental horizontal and vertical control for the surveys and maps but almost all of the actual location of artificial or natural features is done by the other organizations. It is understood that the officers of those two organizations have given consideration to the question of map-making by aeroplane photographs. It is hoped that aeroplane surveying can be developed at least to supplement the usual surveyor's methods in mapping the interior on a comparatively large scale map with high accuracy.

It would appear that if the aeroplane photograph will be of so much assistance in the topographic work along the shores of the country that it would really be of some value in the interior.

Whether or not it is possible to make contours from aeroplane photographs is a question that has not yet been decided. Many persons who have studied the question claim that it is impossible to locate accurately contours from aeroplane photographs. Others claim that they can be located with great accuracy. The chances are that some mean position will be found to be the true one. It is possible that the stereoscopic methods can be applied to two photographs taken by two cameras on the same aeroplane or by cameras on two different aeroplanes together to obtain a rough idea of the configuration of the country.

It is possible that the topographer would be able to place the topographic details on his map from the photographs before going into the field to do the contouring. Much of the work of the topographer by the usual methods consists in placing the topographic features on the map in their proper location, but a great deal of this might be obviated by the use of the photographs. Then he could go into the field and place the contours with greater rapidity than if he attempted to do so previous to using the details of the photographs.

Aerophotographs for Revising and Bringing Maps Up to Date. What I have stated above in regard to original surveys by aero-photography, in the three classes of high grade maps, are simply opinions or prophecies. These are the coast charts, the contoured maps of the interior, and maps which show all features except contours, but I feel confident in stating that even on the highest grade of topographic maps, the aerophotographs can be used to a great degree in revising and bringing up to date maps of that character which have already been made. Let us suppose that we have before us a topographic map made by the U. S. Geological Survey, say ten years ago, and let it be supposed that this map at the time it was made, was absolutely perfect. The map is supposed to show the contours, woods, streams, houses, and other features that are usually represented on such a map. In the ten years since the map was made, it is reasonably certain that some changes have been made by the works of man. It is improbable that natural features would have changed, such as streams, woods and hills, during such a short period. We may assume that new roads have been made, old buildings torn down, or have burned, and new ones erected, wooded areas have been cleared, and brush or young trees may now be on areas that were bare at the time that the original survey was made. In order to test such a map and learn whether it was up to date, it would be necessary by the usual methods, to send a surveyor into the field to go over the area in great detail. Of course an inspection could be made of an area by driving over it, but many changes might be overlooked by this method of inspection.

How much simpler and more reliable it would be to send an aeroplane over the area in question and make a series of photographs. These photographs would show at a glance, the exact areas where changes in the features had occurred, and if the changes were not too complicated it is probable that we would be able to place the new features on the map directly from the photographs. The process would be to fit in the new features between unchanged old features, which of course would also be shown on the photographs.

In what has been said above, it has been assumed that the photographs have been made with the camera vertical, or, in other words, with the photographic film or plate in a horizontal position. It is only in this way that absolutely accurate photographs could be made. If the camera is tilted from the vertical at the instant the exposure is made, then there will be a distortion of the photograph so far as the map is concerned. If this tilting were known, then the photograph could be rectified and the features shown on the map with the same accuracy as if the plate had been horizontal at the time of the exposure.

It is hoped that methods will be developed for holding the camera in a vertical position at the time of exposure. I know of none now in use which is entirely satisfactory.

Wages of Electric Railway Employes, 1906-1919.—The average rate per hour paid trainmen on the electric railways in this country was 23.03 ct. in 1906 and 44.43 ct. in 1919. These figures are based on wages paid by approximately 60 companies having over 100 miles of track each. The following table taken from information submitted last July to the Federal Electric Railway Commission shows the average rates paid in the period 1906-1919:

Year.	Rate per hour, ct.	Per cent increase.
1906	23.03	.....
1907	24.11	4.69
1908	24.75	7.47
1909	24.57	6.69
1910	25.85	12.24
1911	26.10	13.33
1912	26.89	16.76
1913	27.71	20.45
1914	28.14	22.23
1915	28.62	24.27
1916	29.25	27.01
1917	31.37	37.08
1918	33.92	47.29
1919	44.43	92.92

The rate per hour given above is the average rate of all companies reporting, based on that paid to men oldest in the service.

A Suggested Form of Cost-Plus Contract

By G. H. HAILEY,
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There has been much discussion recently of the various methods of awarding contracts, all of which is very wholesome, as out of it may finally be developed a form which will be more or less universally adopted, thus relieving the contractor, as far as possible, of all elements of chance, and at the same time affording proper protection and justice to the owner.

In the old days of contracting all the burden was placed on the contractor; he had to take all chances; with floods; with the character of materials encountered in excavations; with the whims of the owner as to changes in plans and as to suspending work; with "anything omitted (through owner's carelessness) from the plans and specifications but necessary for the proper completion of the work" in the owner's opinion; with the increase in price of materials and labor and many other unknown conditions that might arise. These, together with the old "hit or miss" fashion of bidding resulted in the contractor either making an unfair profit or going broke and in the latter case, when it was seen that the contract was a losing one, there was the temptation to "skin the job," out of which grew the opinion among a considerable number of people—in some cases justified—that contractors were grafters and crooks. Especially did this opinion exist as to contractors on public work. With the development of engineering and the entrance of the engineer into the contracting field, more equitable contracts are being drawn and the work of estimating, bidding, contract letting and construction is on a more scientific and businesslike basis and the contractor of today ranks among the best business and professional men of the community.

If we can develop a form of contract that will offer the maximum amount of safety to the contractor and at the same time insure fairness to the owner, it is obvious that the latter will be able to pick the highest type of builder, will get the work done at a minimum cost and there will be no more bankrupt contractors to cause delay, loss and inconvenience to everyone concerned.

In the July 23rd issue of Engineering and Contracting a well known engineer contributes an enlightening discussion of a number of different forms of contracts and suggests one form as especially meritorious. He, however, omits one method that has been used extensively and which, in my opinion, is the best of any so far suggested although it is similar to one of the forms he discusses. It is the "cost plus unit profit" method.

Everyone will concede that the "lump sum for complete construction" and the "schedule rates for all materials in place" methods force the contractor to take all the risk. They are, therefore, unjust to both parties as the contractor must either add a large amount to his price to cover these uncertainties or, unless he can stand the loss, being forced to abandon the job, with the resulting delays and expense to the owner.

The question, therefore, of a mutually fair form of contract resolves itself into some cost-plus method.

In the "cost plus unit profit" form the contractor is paid for the cost of the work plus a unit price for all classes of work performed, the unit prices to cover the use and depreciation of equipment plus profit.

As an example the bids on a concrete bridge would be received at cost plus the following unit prices:

Dry earth excavation, per cu. yd.......... ....
Wet earth excavation, per cu. yd......... ....
Dry rock excavation, per cu. yd.......... ....
Wet rock excavation, per cu. yd.......... ....
Cofferdam lumber, sheeting, bracing, etc., per MBM. ....
Foundation piling, per lin. ft... ....
Concrete, per cu. yd.......... ....
Steel, per lb. ....
Waterproofing, per sq. yd..... ....
Backfilling, per cu yd................... ....

The above form insures the contractor against loss and at the same time protects the owner for the reason that an increase in the cost of the work not only does not cause any increase in the contractor's profit, as in the various forms of cost plus percentage contracts but causes him to extend the use of his equipment for a longer period without pay. This, of course, is true also in the cost-plus-lump-sum method but the objections to the latter are: (1) That it requires a careful estimate of all quantities in the structure in order that the contractor may arrive at the proper lump sum whereas in the "cost plus unit price" form no such careful estimate is required as the unit prices take care of any increase or decrease in quantities. (2) Where the amount of work is increased or diminished, the difficulty arises, often very serious, of making the proper increase or decrease in the lump sum. (3) Where it is important to start work before plans are fully completed, the cost-plus-lump-sum method cannot be used for there are no means of arriving at the proper lump-sum.

The disadvantages I see to the method suggested in the issue of July 23rd, are: (1) The burden is placed on the contractor the same as in the old forms for he is required to guarantee a limiting lump sum expenditure to owner, and must take all chances of increases in cost of materials and labor. (2) It requires a careful estimate of the job and in such work as the recent war emergencies it is impossible to estimate the job since it must be started before plans are completed; (3) It does not prevent the question of "extras" rising which is the most troublesome point in settling for all construction work.

Assuming that the "lump sum for complete construction" and the "schedule rates for all materials in place" are unsatisfactory, as nearly all will concede, then it would seem that the advantages of the cost-plus-unit-profit method over all other cost plus forms except the cost plus percentage form, the vicious effects of which have been demonstrated during the recent war emergency work, are as follows:

(1) It relieves the contractor of all undue risk.

(2) It thereby lessens the cost to the owner since it is not necessary to include anything in the price to cover such risks.

(3) It prevents any arguments over the question of extras.

(4) It takes care of the question of rental of equipment in case quantities are increased or diminished, since there will be a corresponding increase or diminution in the profit through the medium of the unit prices.

(5) It requires no accurate estimate of the proposed work.

(6) It requires the minimum of labor in cost keeping.

(7) It is especially adaptable to work which it is desired to start at once but for which complete plans have not been prepared, such as the recent war contracts. It is obvious that none of the other cost plus methods (except the pernicious cost plus percentage form) can be used in such emergencies as all require a careful estimate of the quantity of work to be done before the contract can be made.

The above ideas are given for what they are worth. I know that in the cases in which I have used the method that I have outlined, both the owners and contractors were well satisfied and in not a single instance did the bothersome question of "extras" arise.

It would be well worth while for the American Society of Civil Engineers to go into the question of contract forms with the view of using its prestige to urge the universal adoption of a standard form keeping in mind its adaptability to all kinds of work, including emergency construction, for that was the cause of so much recent public work being let on the cost plus percentage basis.

There was so much adverse criticism of the percentage form in recent war work that a bill is now before the Congress prohibiting the use of any cost plus form of contract on Government work. Such a broad prohibition would unquestionably be a great disadvantage to the construction department of the Government and the various engineering bodies should unite with the Contractors' Societies not in simply opposing the present bill, but in offering a wise and practical measure in its stead, providing for some equitable cost-plus form, along the lines I have suggested above, that could be used by the Department at its option, especially in emergency work.

$6,000,000,000 Invested in Electric Railways. According to statistics submitted to the Federal Electric Railway Commission, the investment in the electric railways of this country amount to $6,000,000,000. There were 44,000 miles of track and 300,000 employes. On May 31, 1919, 62 companies, with a total mileage of 5,912 were in the hands of receivers.

The Future of Traction Companies*

By P. J. KEELEY,
President, Kansas City Rys. Co., Kansas City, Mo.

In my mind the ultimate solution will be private operation and ownership with municipal supervision of service based upon the cost of service principle, which necessarily will include a fair return to capital actually and honestly invested in the public service.

The cost-of-service plan primarily turns upon two fundamentals: First, that the car rider shall pay only for transportation; second, that inasmuch as one element of the cost to produce is a fixed return upon capital value, that such capital value be determined and agreed upon between the company and the municipality.

To some extent, from the standpoint of valuation, the doors of the past have been closed, and the entire transportation problem is in a fair way to be put upon a present and a future basis. The valuation cycle has progressed far enough so we can be at least hopeful that the standards in many cases being adopted, and which include the points developed in the recent report of the Valuation Committee of the American Electric Railway Association, will govern the majority of future valuation proceedings. Although the whole question of valuation is complex, its basis of common honesty and fair dealing is becoming universally recognized. We have traveled a long way from the principles established in the beginning by the Wisconsin Commission, where valuations for rate making purposes were made on the depreciated physical value plus some additional allowance for a going concern. The trend of rate making today is away from the idea of basing rates on depreciated value. It is now recognized that it is a physical impossibility to keep any property maintained to a condition where no depreciation exists; that no property can possibly be maintained at more than 80 to 90 per cent of its cost new value, and that when maintained to that condition it will, as far as the public is concerned, be giving 100 per cent service. In basing rates on the depreciated value of a property the investor is not only penalized in that at least 20 per cent of the investment which he never had an opportunity to recoup is being confiscated, but the public also suffers. From the latter viewpoint, if, in determining fair value, accrued depreciation is deducted, in the future the rate of return must be sufficient to include an allowance for future depreciation accruals, yet such accruals can never be used for public benefit, since it is impossible to keep the property maintained at more than 80 to 90 per cent physically good. Therefore it follows that it is more expensive and increases the cost of service for the public to pay the principal by paying for accrued depreciation than to pay interest on the cost new value without deducing depreciation. Furthermore, it is now recognized that depreciation charges have nothing to do with capital account but are chargeable directly to operation.

The Wisconsin Commission, which first originated the principles of basing rates on depreciated value, has within the past year abandoned this theory. The Buffalo arbitration fixed values entirely on the cost to reproduce new. The Missouri Commission has similarly expressed itself and in a recent case states that henceforth all valuations in Missouri for the purpose of rates making would be on the basis of cost to reproduce new. This position is economically and morally sound, and I believe is one which will be made the basis for all future valuations of traction companies for rate making purposes.

From every present indication the future of traction companies lies along the way of private operation based on the cost of service with sufficient public supervision to insure proper costs and adequate service. The car rider should not be made to pay for anything but transportation. This means traction companies shall be relieved of all indirect taxes, such as paving charges, sprinkling, snow removal, and other taxes of like nature. It implies a fair agreed valuation upon which the car rider will pay a reasonable return; it further implies public supervision and a reward to management for efficiency.

There can be no proper argument advanced why transportation should be furnished at less than it cost to produce, and the deficit made up by taxation. If this is reasonable, then it is reasonable to go a step farther and say that transportation should be assumed by the municipality and furnished free and all expenses borne by taxation.

The street railway problem is in some ways a psychological one. Although the fetish of the 5 ct. fare has been successfully abandoned, its memory still lingers. A raise in rates has generally meant that there is a loss in the number of passengers carried. In other words, in order to register a mental protest against a fare increase, many people resort to the sidewalks. These same people, however, do not refuse or object to paying the price asked for any other product, and in no other line of business other than transportation has increased price meant decreased volume. This attitude is changing and will continue to change for the better. Just as soon as the public becomes thoroughly convinced that in order to have urban transportation the cost must be paid by the car riders, our short hauls will come back. Mixed with this has been an element of ill-will and suspicion. Politicians and newspapers have played upon fare increases with the result that the public has heretofore thought that it meant an additional gouge. There has existed in the public mind doubt as to the actual cost of the service. However, this should be temporary. The present national investigation will clarify the situation, and the cost-of-service plan presupposes a new basis for our dealings with the public. Service costs and service standards will be set up under public authority. There will be sufficient checks and safeguards to assure the riders that in paying the ruling fare they are only paying what the service cost plus a fair return on an agreed and established capital investment.

Whether or not a satisfactory solution can ever be made for labor is a question that will always be doubtful. If the future is to be judged by the experiences of the past 24 months there seems to be no way of satisfying labor. The demands of the union have already upset settlement after settlement that seemed to premise results. There is one element, however, in the situation that may curb further unreasonable demands, and that is public opinion. In the past the public in paying a fixed fare was very little concerned with the troubles between the traction companies and their employes as long as service standards were maintained. In general the public sided with labor for the simple reason that, paying a fixed fare and receiving good service, it was not directly affected. However, under the cost-of-service plan all this will be changed, and when the public once realizes that further wage increases and work-day changes are immediately reflected in the cost of service, public opinion will be interposed to offset unreasonable demands. It has frequently been said that many of the troubles of public service corporations can be traced to "the-public-be-damned" attitude of a decade ago, whether this is true or not, and it will be very interesting to see what will be the result of "the-public-be-damned" attitude of labor.

It may be that the zone system is the solution in some localities, although as yet it has not been given sufficient trial in the United States to draw definite conclusions. The great majority of our cities have grown upon the basis of one fare and it will be an extremely difficult matter to change the very fundamental upon which their growth was predicated; that is, the one-fare system.

There is this much that can be said upon the future of our transportation systems. They are absolutely essential to the growth and development of our cities; there is nothing today or in the near future that can take their place; what is necessary to our present civilization will be continued and maintained. The entire industry is today going through a settling process that will put it upon a more secure and stable foundation than ever before. Being removed from a local status to a national one, valuation and other standards will be more easily adopted. The public, to the extent that it will be given a more direct control of service and have the assurance that it is paying a fair price, will to that extent assume the responsibility for this service.

The investor will find a future that will assure him of a fair if small return upon the money he has actually invested to give transportation service to our cities. The public will be satisfied because it will have the assurance that it is paying for the service which it demands a fair price based upon its actual cost and that it controls more or less directly the character and extent of its service. Labor will be made to realize that it is engaged in a public service and that public welfare must be considered. It will be paid a fair wage for a fair day's work and unreasonable demands will be met by the withdrawal of public support. The door of the past, I believe, will be closed not only upon obsolete valuation methods, but upon all of the old prejudices which have been the outgrowth of past mistakes and past policies. The urban transportation industry will be established on a business basis in which it will receive a fair price for a service absolutely essential to the wellbeing and growth of our cities.

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*From a paper presented Sept. 8 before the Western Society of Engineers.

Government Control of Transportation in England

The transportation problem in England, as in the United States, has become a very serious one, during the past few years, and in the effort to solve it the British Government has had its plan for transportation control adopted by Parliament after a remarkably short campaign, writes the European editor of the **Railway Age.** It is a very remarkable bill which has been passed in a short time in that it places under the control of one man, the Minister of Transport, nearly all the transportation facilities of the country, including railways, waterways and highways of every description, the only exceptions being that in the case of docks and highways the authority of the minister is somewhat restricted.

The reason for such a bill passing both houses of Parliament in as short a time as six months is given by this writer as the desperate condition of transportation and the fact that as no different plan had been offered it seemed to be a choice between this plan and direct nationalization of transportation facilities, and the lesser of two evils was chosen. In spite of the revolutionary character of the bill, the administration claimed that it was not necessarily a step toward nationalization and that it was necessary for the government to take this step in order to tide over the handicap and distress put upon transportation by the war.

The bill is known as the Ways and Communication Bill and is to remain in force for two years: by the end of that time it is hoped that the best policy for future control can be determined. It is expected that expenses may be reduced by eliminating competition, pooling equipment, and using larger cars and locomotives.

Thus England has settled for two years, at least, its transportation problem. The roads, which since the war have been marking time, may now expect to take definite action on long deferred improvement programs. There unquestionably will be a development in electrification of the roads, deferred maintenance will be systematically taken up, standardization will be given consideration, larger cars undoubtedly used, and marked changes will be made in the consolidation and joint operation of the properties.

Sir Eric Geddes, who is Minister Designate, in a speech on the transport bill and its provisions, has stated that there will be an elimination of services simply given for the purpose of competition. The private freight cars, of which there are about 700,000, will be eliminated. There will be judicious electrification where the decrease in the cost of production by this method warrants. The rolling stock will be gradually brought up to the best standard and the loading gage will be improved.

In this speech Sir Eric Geddes outlined his proposed organization, stating that with the one exception of roads (highways), which must be treated as a separate department, it is proposed to organize the Ministry in different branches—civil engineering, mechanical engineering, and so forth.

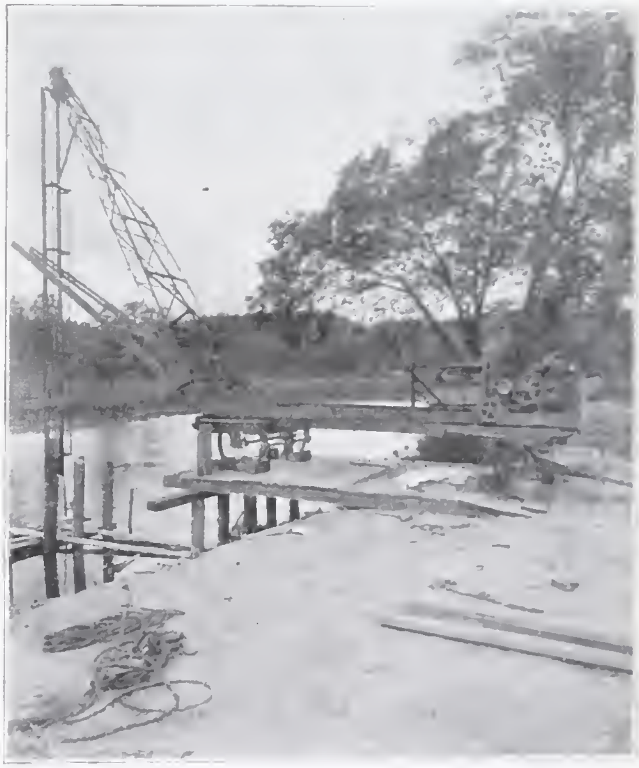
Texas Has Surveyors' License Law.—The new law for licensing land surveyors in Texas, which goes into effect on Oct. 21, 1919, provides for the creation of a board of examiners consisting of the State Land Commissioner and two surveyors who shall be appointed by the governor. This board will prepare questions pertaining to land surveying generally and the law of land boundaries. The examinations will be conducted by the county boards of examiners of applicants for teachers' certificates, but the surveyor's board will grade the answers and issue licenses. A surveyor's license will be good for life, unless revoked for improper conduct. Applicants will pay a fee of $10. Surveyors who have been actually engaged in the field for 15 years may, upon payment of a fee of $2, obtain a surveyor's license without examination.

Portable Piledriver Has Many Uses

By GEORGE F. PAUL

A portable piledriver that can be converted readily so as to be used as a derrick for excavating purposes or for digging holes for telephone posts, has been perfected by Capt. Alexander M. Bellony, Engineers, U. S. A. This piledriver has a gross weight of 8,200 lb., is mounted on trucks and can be quickly transported by horses or a motor truck to positions where its use is required. The 950-lb. hammer with which it is equipped permits piles to be driven in 25-ft. leads. On the main stationary frame a movable frame is mounted, and this frame in turn carries the A-frame boom the hanging leads, the engine and the hoist. When the machine is being hauled about, the boom and leads fold down, the middle of the folded portion being supported on a timber cushion.

The A-frame boom is pivoted to the sides of the upper frame. The leads are 25 ft. in length, with a spread of 17 in. From the bottom of the wheel to the top of the leads is 32 ft., making it possible to take a pile nearly 30 ft. in height above the wheel base. A locking hanging device connects the leads to the boom; buffer blocks are placed at the upper end of the leads. Sway braces are used to stiffen the leads, the inner ends being pivoted near the foot of the boom. Besides, there is a lead cable-stiffening device. This consists of two hand winches, one bolted to each side of the upper frame, with cables reaching from the winch to the leads. These cables travel through spools on the ends of the extension track.



Method of Blocking and Operating Portable Pile Driver.

At the front and rear ends of the lower frame is a circular track that extends beyond the sides. The extended parts of the track fall flat to the sides of the lower frame whenever the rig is being moved. Five rollers are placed at each end of the upper frame, and besides a pinion is provided on the front end traveling on a rack located on the lower frame. The center of the frame has a pivot pin that forms the rotatable axis. Thus the upper frame can be rotated to any desired position. This makes it possible to drive a straight line of piles in a length of 25 ft. with an extreme reach of the leads of 16 ft. This saves the moving of the machine and merely calls for the turning of the upper frame and the adjusting of the leads and boom.

The 950-lb. drop hammer is operated by a 20-HP gas engine located on the front end of the upper frame. To the engine is connected the hoist operating the drop hammer. The different uses to which this portable rig can be put is making the outfit a favorite for army engineering work.

The Clyde Iron Works, Duluth, Minn., built the first machine and tested it out under actual working conditions on the St. Mary's River, Duluth, and on the Potomac River, at Camp A. A. Humphreys, Virginia. The Flour City Ornamental Iron Works, Minneapolis, has built 21 of these machines for the Army and the Clyde Iron Works has built 12.

Present Causes of Unrest and Radical Economic Theories Not New

In an address two weeks ago at the Our Country First Conference of the Illinois Manufacturers' Association, Mr. Dorr E. Felt, President of the Association, called attention to the fact neither the present causes of unrest nor the various radical economic theories were new, and stated that the present need of the moment is sanity and sincere co-operative effort on the part of all classes of Americans. An abstract of his address follows:

Utopian Theories and Artificial Legislation.—At present our greatest danger rests in the possible acceptance of Utopian theories and the attempt to apply in times of peace artificial industrial and legislative measures which, no matter how necessary and excusable in war time, are not practicable under peace conditions when public sentiment will not sanction increased national indebtedness and excessive taxation. Stimulants and palliatives administered during the stress of war may be disastrous if the dosing is continued under normal conditions.

The proponents of most of the so-called new thought ideas who talk so much about looking forward are not taking the trouble to look backward or they would know that practically all of their supposedly new discoveries are not new at all and have been tried out time and again in many countries with unhappy results. In the matter of prosperity, legislation will not take the place of honest work and capable management.

Arbitrary price fixing during peace times has always resulted in the stopping or restriction of production and ended in conditions of great distress and scarcity of the necessities of life. A great Roman emperor, 301 years after Christ, attempted to reduce the cost of living by establishing a maximum price on nearly 1,000 commodities. The result was stagnation, higher prices and bloodshed, so that the producing factors of society had to start all over again to rebuild in normal and natural ways.

Profit-sharing and workers' participation in management, which began in Great Britain about 1835 and culminated about 1885, has been the subject of numerous official reports in England which treat of nearly 300 attempts by such means to eliminate friction between employer and employed and to put a stop to restriction on output by the workers. These reports show that in a majority of cases such efforts were a complete failure. During good times and in the case of firms having more efficient managers than their competitors or neighbors such arrangements, in some cases, seemed to work well; but, in the stress of hard times not only was the friction between the employer and employed increased but various other kinds of friction developed. For instance, the workmen blamed the selling force for not securing orders and the selling force alleged that the workmen produced inferior goods at too great a cost. Each craft involved in production magnified in its own mind its own importance to the industry and right to greater participation in the profits

Experience with Government Promotion and Ownership in 1837.—The greatest panic and disaster ever experienced in this country was that of 1837 following a period of great expansion and prosperity during which the Federal Government and members of the states attempted to legislate prosperity to every one. State and Federal promotion and ownership of railroads, canals, banks and other enterprises had been the order of the day. Some states projected as many as half a dozen railroads each. Speculation and struggle for favoritism ran riot, taking the place of honest construction and production in many parts of the country, ending in prices for the necessities of life much greater in proportion to wages than at the present. The word "profiteer" had not then been coined, but the word "extortionist" was in everybody's mouth. Great mobs gathered in Philadelphia, New York, Boston and other cities. New York warehouses were broken into by a mob which distributed flour to all comers, immense quantities of it being destroyed and spread over the pavement of the streets, the sequel being immediate higher prices for flour resulting upon the dissipation of the necessary stocks stored by men who were, even in that day, called "hoarders."

Will it be necessary, as a result of false teaching by men who never filled a pay envelope and who know little or nothing from a practical standpoint of economic questions, that this generation, now so prosperous, will have to learn its lesson which common sense and a little reading of history might teach without the dire results which are sure to follow if we put into practice the theories promulgated by star gazers?

Common Sense and Rainbow Chasing.—There is not as much discontent as the vendors of news would lead us to believe and most of what there is is manufactured. The great strikes in the Northwest and in Canada were called where the wages were abnormally high and living costs and conditions excellent. This has been true in the case of many other recent strikes in this country. There has always been more industrial strife during prosperity than during hard times.

It would be disastrous for the working people to demand laws conferring on them special privileges and at the same time absolving them from the ordinary responsibility for their own acts. In France they have just passed a law pertaining to collective agreements between employer and employed which provides for the legal enforcement of such agreements and the right of either association to sue and be sued.

Much academic theorizing is leading us away from a clear understanding of economic truths. We are in danger of dissipating the great resources, the industrial and commercial ability of our country. Regardless of the wild socialistic and revolutionary ideas which have been preached to the people of Europe during the last 12 months by the most energetic and widespread propaganda of recent times, all classes appear now to be recovering their sanity.

The ultimate effect of the necessary interference of the Government in industry and transportation for the successful prosecution of the war does not seem to be considered by many. The Government had to procure, regardless of costs, immense quantities of the products of the farm, the mills and the factories, at a time when many men were being withdrawn from their usual vocations. The result is a large national debt and heavy taxation. During war a country must mortgage its future, and the payment of that mortgage is sure to be felt, sooner or later, by every one of its people. Doubtless America will feel it less than any of the other countries which placed large armies on the battlefields of Western Europe.

I believe that if we exercise common sense and avoid chasing the rainbow, the effect of the war will not result in any great hardship in America, but that continual rainbow chasing and agitation will result in grave distress.

Average Wage as Basis for Contract Price Adjustment

As a means for reducing the element of chance in bidding under the present unsettled conditions of the labor market the Northwestern Association of General Contractors suggests that contractors be permitted to base their prices on a sliding scale for labor. The association believes that a paragraph in contracts, similar to the following, would be fair to both the contractor and the owner:

> This price is based on an average rate of wages of — cents per hour, the average rate per hour to be the rate obtained by dividing the total monthly payroll of all men engaged upon the work by the total number of hours shown on such roll. Monthly adjustments, based upon the average rate per hour, are to be made in the following manner:
>
> The Contractor will present to the Owner a statement showing the total amount of his payroll for any calendar month, together with the total number of hours on this roll, and the average rate per hour. When this average rate exceeds — cents per hour, the Contractor is to receive from the Owner the difference between the actual average rate paid, and — cents per hour, multiplied by the number of hours shown on the payroll. When the actual rate paid is less than — cents per hour, the Contractor is to have deducted from his monthly estimate an amount equal to the difference between the actual average rate per hour and — cents, multiplied by the number of hours shown on the payroll.

How to Keep the Human Machine in Working Order*

By DR. THOMAS DARLINGTON.

Medicine has opened a new field, particularly in prevention of disease, and we have begun to consider man in a different light. We know, and have known for a long time, that it pays to take care of an accident, and we know that it costs something every time a man loses his finger. It used to be, even 10 years ago, that in some of the steel plants when men became injured the wound would become septic in fully 50 per cent of the cases. Today in various plants, the United States Steel Corporation, Carnegie, Cambria, and Youngstown Steel & Tube, the rate is only one out of a thousand, and in the Bethlehem Steel much less than that. In the big plant at South Bethlehem in four years of accidents, taking every little injury into consideration, 50 or 60 cases a day, there have been only two cases of septicaemia.

The deaths in the army, both from disease and those killed in battle, are nothing compared to those who become ill and die in industry. And how have we looked upon the man in industry and in the army, and how have we been treating him? We think that hardship hardens a man, and we look at the brown faces of the men that have come from abroad and say they are "hard as nails," but I am thinking of all those that went down, of many deaths, for which there seemed to me to be no necessity. Given a well man, and you have absolute control of him. Why should he get ill?

Relation of Efficiency to Health.—From my standpoint, efficiency depends primarily on health. The German philosopher Munsterberg said it depends on a man's psychology, but what does psychology depend upon? Flow of blood to the brain, and flow of blood to the brain varies with all kinds of things, with the weather, the pressure of the barometer. Suppose your liver is out of order. Don't things have a green and yellow hue? Psychology depends on health. Efficiency depends on health, and it pays to take care of a workman.

As a matter of fact, illness in industry already has an effect on operating costs that is far from being realized. Whenever a man is absent from his work because of illness, it is usually necessary to have someone else take his place. The substitute, as a rule, is a less efficient worker; he makes a smaller output for the day's wages; he spoils more raw material; he requires more supervision from the foreman, who is thus distracted from more important work; and procuring and sending the substitute to the work needed involves a cost and usually a delay in the operations.

Efficiency depends on health, and health depends on three things: the care that a man gives himself, the care that industry gives him, and the making and enforcing of health laws—city, state, and national. What can people do for themselves? Before I take up that question it is proper that I state that I have been told some of the members here are interested particularly in the question of fatigue.

Work Seldom Cause of Fatigue.—Fatigue means much to a worker. If a person catches cold it is when he's tired. If you catch an infectious disease it is when you're tired. Fatigue lessens resistance to disease. Fatigue is the one great thing in this world that we want to avoid. What makes people tired? Work? No. Very seldom. It isn't work. Cold will make you tired. It makes every cell in the body work fast. A great many things make fatigue, but seldom work. That is a different idea from that which most workmen have. How do people get tired? Now, to know that, you have got to understand a little physiology. We must understand the body. Every part of the body is in motion all the time. When any part isn't in motion in the body it is dead. You are manufacturing heat; you are getting energy all the time. That comes from your food. Food goes into the body, is taken up and stored in the body, and you have it to use. It is then burned up by means of the oxygen which you breathe. All the time in the body there is a breaking-down process; all the time there is a building-up process.

Energy depends first upon the food you eat: the kind of food, whether the system can use it or not, whether you digest it and store it away. Next upon the oxygen which is carried by the red blood corpuscles, the hemoglobin in the blood. The first thing, then, in the question of fatigue depends upon the character of the food that people eat. Few persons understand that, and so far as workmen are concerned, few of them or their wives know anything about feeding the man, and any old thing goes in the lunch basket. One day I opened 250 lunch boxes in a Carnegie Steel plant. The first bucket opened contained a whole boiled cabbage. How much C H O did he get to use in the muscle, how much energy could he develop from that cabbage? The next man had nothing but cake and honey. He got all the C H O but what did he get to make up for the loss of protein and muscle? Nothing, and he was thin.

Energy and Food. But it is not alone a question of the kind of food that he gets. Does the man digest that food? Was it mingled with bacteria in the mouth and fermented in the stomach? Did the sugar split up into acids in the stomach before it got into the muscle? Don't you see that energy is the converse of fatigue and fatigue the converse of energy? Energy depends first upon food and its digestion, its absorption and utilization, and next how are you going to burn it? It is burned with the oxygen. Take a drop of blood from a man and examine it under the microscope and we find that he has a 5,000,000 blood count. Yes, that is a good healthy man. It is up to normal. The next man we take we find he has 2,500,000 blood count. Doesn't it take twice as rapid the circulation of the 2,500,000 to carry the hemoglobin as with the man with the 5,000,000? Yes, the blood has to work twice as fast because he has anaemia. What does anaemia come from? Dark, unventilated rooms, infectious disease, poor food, lack of movement from the bowels, bacteria in the mouth, in the tonsils.

Next, getting rid of the ashes of waste. And how do we do it? The blood takes it up and takes it away. If a person drinks a great deal of water, that helps. If you have a shower bath, you drive the blood inside, and then it returns to the surface again, and that helps, and soon you get rid of all fatigue, and the waste goes out through the kidneys. But other waste produces fatigue. In fermentation we have bacteria in the bowels all the time. In fermentation, particularly of protein food, you develop certain poisons. These poisons are known as indol, skatol, mercaptan, and certain phenols. The last develop particularly from eggs and milk. The most common poison found is indol. That is absorbed and becomes a sulphate in the system, and that is known as indican. When you have a urine examination you see so much sugar, so much albumen, and so much indican.

To show you how it works and how a lack of regularity of the bowels produces fatigue: A man gets up in the morning, and he hurries. He goes to work. He has got a lot to do, and the small amount of liquid material in the lower part of the bowels is absorbed and the desire to evacuate the bowels passes off. The poison is taken up by the blood and permeates all the muscles of the body, and the man becomes tired.

This has been proved numerous times by injecting indol into the blood of perfectly fresh men, birds and animals, always with the same result, fatigue. The man has only about a little more than one-third the efficiency of the other man, so far as his actual muscular capacity is concerned. If the one man is worth $6 a day, this man is worth $2.30.

Personal Hygiene. I said that a man's efficiency depends upon what he can do for himself. Now, among the many things of personal hygiene besides the question of taking baths, care of the eye, the ear and the nose and everything else of that kind, and regulation of a man's meals, there are simple things like the brushing of teeth. How many workmen in the factory brush their teeth every day? To be efficient men they must brush their teeth seven times a day. Do you suppose any of your workmen know that? Not a one of them. Why must they do it? The manufacturer is interested in it because of his output. If I had a factory I'd make every man a present of a toothbrush. It was done in the army. I helped to take care of 50,000 men, and had to talk to them. Pneumonia killed some of them, because they didn't brush their teeth. What did they do with the toothbrush? Used it around the edges of the shoes to get the mud out. What is the first thing about the teeth? Well, we need them for enunciation. In the army it was absolutely necessary that orders should be distinct. The chewing of food means a lot in energy. Still, that means little compared with some of the other things. In the mouth are forty-eight varieties of bacteria. If you chew the food without brushing the teeth you swallow those bacteria, and the food ferments in the stomach, and often it passes the quarantine of the stomach and goes down to the bowels.

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*Abstract of an address before the Mining and Metallurgical Society.

The gastric juice of the stomach will keep indefinitely, but swallow saliva and it quickly spoils from contamination with the bacteria that the saliva carries down. Do you know that in the army in the grip epidemic few if any died from grip? They all died from pneumonia. Why? There are four types of pneumonia germs. Nearly all died of the fourth type. That is the mouth bacteria. They got the grip, and then the pneumonia bacteria that inhabited their mouth and grew there went into the lungs and killed them. If they had all brushed their teeth regularly, many of them would have lived. Many, very many of the 600,000 persons that died in the United States, would be alive today if they had brushed their teeth in that epidemic. But that is little compared with the other thing. A tooth dies, but you do not always know it. At the root of that tooth there comes a very small abscess. From this, bacteria and the toxin are absorbed in the system. Just the same as in the tonsils. The tonsils and the teeth make over 90 per cent of our infectious disease. The poison may go into the heart, producing vegetation of the valve; or go into the kidneys, and make Bright's disease; or go to the bladder and make inflammation of the gall bladder. Nearly all rheumatism comes from bad teeth.

Do your workmen know that anaemia, the loss of the red blood corpuscles which carry the oxygen to the tissues, is often due to abscesses at the roots of the teeth or old roots in the mouth? Have you got a dentist in every factory pulling out those old roots? No. The first thing I did at Hog Island where I was consulting surgeon was to put three dentists there.

Deaths from shock and hemorrhage! Men die in a few minutes from shock, but if you have blood to inject into them right away you often may save them. We hired three men, and gave them $1,200 a year apiece and fattened them up and kept them raking leaves, and when a man got injured we took some blood from them and injected it into the injured person. We saved three men worth $5,000 each according to the Pennsylvania Compensation Law the first month—$15,000 against $300 in the first month!

"How about washing of hands? It is from dirty hands that bacteria get into the mouth. What does the surgeon do? Simply wash his hands? No. He puts on rubber gloves, even after he has put his hands into absolute alcohol with bichloride. Take the case of "Typhoid Mary." How did she give typhoid to twenty-eight different families? Because she had typhoid germs on her hands. Very little—but it gave disease. Does every workman wash his hands before he eats lunch?

There is one thing that workmen generally do not know. The man who does not sweat does not live as long as the worker. To live long you have got to work. Work leads to longevity. The rich man of today, what does he do? Does he do like the man in the Bible who said, "Now, soul, we will enjoy ourselves and eat, drink and be merry"? The rich man today builds an 18-hole golf course and works like the devil to keep his health. Work doesn't hurt anybody.

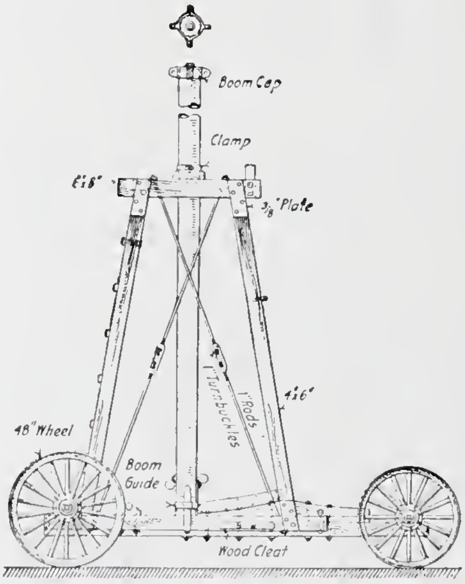
That is what we have got to teach the workman.

We have in the neck a gland called the thyroid. We have more important ones over the top of the kidneys, little thin glands called the adrenals. There are like the governor on an engine. They control our circulation. If you lose those glands, you die. These adrenals throw out a powerful drug. I know of two men on the front where a big shell burst and adrenaline was thrown out so that every hair stood on end for a week. A grouch, grief, anger, or worry are ruinous to the body. They cause adrenaline to be thrown out. But joy, love, laughter prolong life. What does that mean? It means that we must teach the employe cheerfulness; that every man shall find in his daily work his greatest happiness. Just as God Almighty found happiness in the creation of the earth, we, made in His image, must find our happiness in our daily work, no matter what that work is.

We now come to another side of it, and that is this: Cain's answer by the Garden of Eden was, "Am I my brother's keeper?" The Bolshevists and the Socialists have used that for a great while, this cry of the brotherhood of man, which means nothing to that class. When I was in the Department of Health we had 187 laws. They all meant one law. How can you translate them into one law? The man that loves his neighbor won't spit on the sidewalks. He won't sell his neighbor bad food. He won't let smoke come out of his chimney. He won't let his child with contagious disease run around and spread the disease. That is the thing that we must teach workmen—the love of their neighbors. It is a great thing to relieve suffering. It is a far greater thing to relieve penury and crime, so we can say with Abou Ben Adhem, "Write me as one who loves his fellow men."

Portable Derrick for Raising Poles

A portable derrick that has been found very useful in raising poles for electric transmission or distribution lines is illustrated below. The arrangement was devised by the Public Service Co. of New Jersey and is described in a recent issue of the Electrical World. It consists of a four-pole wooden structure, the top cross-arms of which support a mast. At the top of this mast is a boom cap and at the bottom there are eyelets for attaching the boom. The end rope for the block and tackle is attached to the end of the boom and runs through the hole in the boom cap. Poles can be brought to a vertical position by means of an arrangement for rotating both mast and boom about the mast bearing as a center.



Derrick Mounted on Low Hung Truck for Raising Poles.

Stopping Waste and Leakage in Use of Compressed Air.—An instructive lesson in compressed air economy may be learned from the experiences of the Bethlehem Shipbuilding Corporation, Ltd., at the Fore River yard. Operations had begun there with 150 to 160 riveting gangs, and in a few months the force had increased to 300 gangs, but even with the former number the air supply was often short, and the pressure would go down to 50 lbs., instead of the 80 or 90 which should have been maintained.

When the shortage had become critical, seriously delaying operations, a thorough and systematic investigation was started by direction of the general manager, Mr. S. W. Wakeman. A twelve-man patrol was sent out to find and stop leaks and the shops were policed. All leaky hose was doctored or discarded. Blowing snow off the work by compressed air was stopped. Posters in prominent places did effective educational work.

In a short time the air consumption, which had run up to 60 cu. ft. per min., per riveting gang, was brought down to nearly 30, and then to 25 or lower. On the biggest operating day, Aug. 1, 1918, there were 315 riveting gangs at work in the yard, yet the pressure held steadily up to 90 lbs.

Addition of two 5,000 cu. ft. electric driven compressors increased the previous capacity of 12,600 cu. ft. per min. by piston displacement to a total of 33,600 cu. ft.

Before these new machines were put in a 1,000 cu. ft. compressor was hired, and later two 1,700 cu. ft. machines were borrowed from the equipment built for the new Squantum plant. Except for these two temporary additions, however, the old installation had to carry the load. A year ago the air consumption ran up to 11,000,000 cu. ft. in 24 hours; the present consumption ranges from 8,000,000 to 9,000,000 cu. ft. in spite of a 50 per cent increase in the number of gangs working.—Compressed Air Magazine.

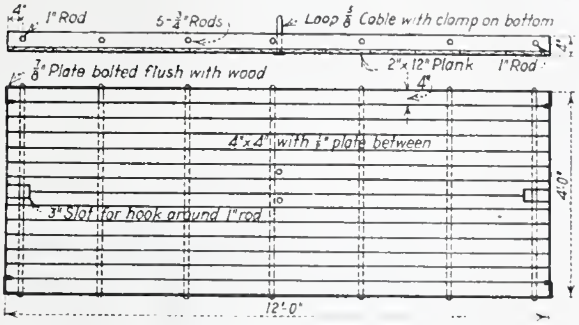
Steam Shovel Operating Kinks

Useful suggestions for getting the best results in steam shovel operations are given in a recent issue of Successful Methods. The matter following is taken from that journal.

The output of a steam shovel depends mainly on the energy, skill and brains put into the work by the operator. This means taking good care of machinery and operating it with judgment.

A loose bolt or improperly adjusted gear or bearing will produce a knock which is the forerunner of a knockout. Make temporary repairs yourself so that the shovel will continue to operate until such times as permanent repairs can be made.

Wooden platforms used for shovels equipped with broad wheels may be made as shown in the figure. These sections are moved by the dipper arm with the aid of sling chain. An expert operator will lift, swing and drop the track sections in a correct position. Make the platform sections of hard, tough lumber.

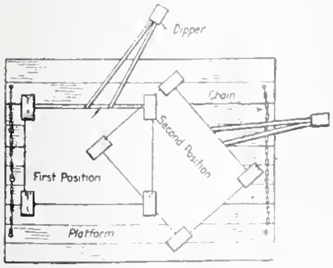

4"
1" Rod
5-¾" Rods
Loop ⅝ Cable with clamp on bottom
2"x12" Plank
1" Rod
⅞" Plate bolted flush with wood
4"
4"x4" with ⅛" plate between
3" Slot for hook around 1" rod
4'0"
12'-0"

Section of a Shovel Platform.

Have the pitman place the track or platform according to material below. This prevents trouble and reduces wear and tear.

Turn the shovel by traction device or skidding. Skidding can of course be done only on a platform. To skid the shovel the platform sections under the shovel are chained together and the near rear wheel is chocked to prevent forward movement. The dipper is thrust vertically downward to a firm bearing, and on being subjected to a slight pressure raises the boom, taking the load off the front wheels. Manipulation of the swinging and traction levers forward gives thrusting force which produces a lateral slipping of the front wheel and a combined lateral and forward movement of the wheels on the opposite side of the shovel. The nearest rear wheel turns on a pivot or moves backward slightly. If the platform is slippery the shovel may be skidded by simply setting the boom and operating the swinging engine without chocking the wheel. Skidding may also be done on a dirt foundation by feeding 4-ft. plank under the wheels.

Skidding makes it possible to turn the wheels of the shovel completely around in the minimum time and to proceed in a new direction. In foundation excavation this enables the shovel to turn at right angles or completely around in not more than 3 minutes. But the movement must be effected with good judgment and care to prevent injury to the shovel.



Method of Skidding a Shovel.

A full dipper load with the least possible effort in the shortest time is the primary object of the operator. The kind of material dug is an important factor. For example, if the material is shale-like clay it requires slow thrusting and lifting movements in order to give enough time for fracturing the material. A tough but soft clay may be peeled off in thin slices. Rock excavation calls for poising big fragments on the dipper teeth and picking up the smaller fragments together. The operator must use foresight in loading each dipperful in a manner that will prepare the way for getting a succeeding dipperful.

When the boom swings low the "reach" is increased and the "clear lift" is decreased. Adjust the boom so that the shovel weight and the dipper load will balance when swinging. This reduces wear on the machine. Lengthening the boom supports increases the operating wear. Make the complete operation of digging, swinging and unloading one continuous movement. Coast the dipper to relieve the boom and engine for a short distance at the end of the delivery swing. This frees the engine cylinders from steam and leaves them in readiness for the reverse movement which returns the dipper for reloading.

Carelessly effected delivery injures cars and wagons especially in rock excavation. Common sources of loss of time in handling the shovel are: (1) Failure to place the dipper in the propor position for digging, (2) not stopping the upward movement of the dipper immediately after it is filled, (3) lack of skill in adjusting the elevation and distance of the dipper while swinging so that it will be in readiness for delivery; and (4) failure to release the dipper door immediately when in position for unloading.

American Association of Engineers and Salaries of Railway Engineers

A 32-page progress report issued recently by the railroad committee of the American Association of Engineers contains the entire story of the negotiations which have been carried on by the Association relative to increased salaries of railroad engineers. The salary case of the railroad professional engineer was championed for the first time last October, when the Association asked the Wage Board of the Administration for a hearing at which the claims of these engineers might be presented. This hearing was finally obtained last March, just after a conference had been held in Chicago by the Association at which several hundred engineers adopted schedules of salaries for various positions which were underpaid. The hearing resulted in favorable action by the Wage Board, and the point was apparently almost reached where the Board was to issue a wage order placing new salaries into effect over the entire country. The movement for higher salaries looked like a complete success. Then came the blow. The administration took the matter out of the hands of the Wage Board. The Director of the Division of Operation advised National Headquarters of A. A. E., however that regional directors had been given authority and instructions to make proper adjustments of salaries in their respective regions. It was then necessary to conduct independent negotiations with each regional director. This occupied the railroad department of the Association for almost three months, until, finally, the Northwestern Region issued the first order which had been issued in any region and which granted increases in salaries which brought the new rates approximately up to those which had been recommended by A. A. E. Since then the Eastern Region has announced that its new rates for professional engineers are ready in the rough, although they are not yet printed for distribution. Results are expected also in two other regions before the first of October. The report gives a resome of the history of the case to date, including reproduction of some of the correspondence. It will be mailed to interested persons who send in their names to National Headquarters at 63 East Adams St., Chicago, as long as the surplus copies last.

Cost of Renewing Switches, Ties, Etc., in Ladder Tracks.—Ladder tracks, especially the advance end of receiving and the receiving end of classification yards which are almost continuously occupied, are such that the cost of renewals and maintenance will be high proportionately. There is a considerable unproductive labor time. In an article in the Railway Maintenance Engineer, Mr. J. B. Baker, Supervisor Pennsylvania R. R., states that the average cost to renew switches, frogs, guard rails, cross and switch ties in such ladder tracks, including labor only, is approximately as follows:

Switch points	$4.[illegible]	per point
Frogs	6.0[illegible]	per frog
Guard rails, including plates and fastenings	4.5[illegible]	per guard rail
Switch ties in stone ballast	1.80	per switch tie
Cross ties in stone ballast	[illegible]	per cross tie

A Portable Tie-Treating Plant

Portable machines for various phases of construction work have long been familiar to engineers. One of the latest innovations in this line is a portable wood-preserving plant mounted on railroad cars. This plant is described in the Railway Age, from which the following is taken.

The Pennsylvania R. R. has been using a tie treating plant for the past 18 months that is mounted entirely on cars. This includes not only the retorts but the adzing and boring equipment as well, so that the complete outfit, ready for immediate use, may be transported to the points of principal tie supply and thus save the possible back haul occurring where ties must be transported from the wood lots to the treating plant and then to the point of use in the track. Such a plant is particularly adaptable to districts wherein a large proportion of the ties used are purchased locally and stored along the right of way to season. However, the distribution of ties has been so dislocated in recent months that the plant on the Pennsylvania has operated continuously in the Mt. Union (Pa.) tie yard, where, in 1918, 276,156 ties were treated, adzed and bored at a cost, exclusive of royalties, rentals, etc., of $0.1211 per tie.

Essentially the plant consists of a car housing the power plant and adzing and boring machines, two cars carrying tracks on which the retort cars travel and a car for the treating cylinders. All of these cars are built specially for their particular purposes and are arranged in the train in the order named. The train may be moved from one locality to another as any other train, clearances having been maintained in the design of cars, or it may be moved locally under its own power, the adzing and boring car being equipped with the proper gearing for this purpose.

The adzing car, in addition to containing the adzing and boring machines and conveyors located in one end of the car, furnishes space for a 60-HP. gas engine, a stationary boiler of 50 HP. for generating steam for the operation of the pumps on the treating car, fuel storage for the boiler, tanks for gasoline and kerosene, etc.

The track cars, two in number, are 50 ft. long with two tracks for the tram cars on their deck, with two additional tracks raised on steel frame work to the elevation of the upper cylinder on the treating car. A ball bearing gravity roller conveyor extends alongside the adzing car leading from the machine to the first track car, which is supplied with turntables at the end adjoining the adzing car. Switches at the end of the second car adjoining the treating car permit flexible operation of the tram cars, it being possible to discharge from either cylinder to either side of the track car as occasion demands.

There are three cylinders on the treating car, two along side on the deck, and one superimposed. The treating car equipment consists of two pumps and the necessary gages and valves, one a low pressure pump working to about 200 lb. and used for pumping creosote into the cylinders, and the other a high pressure pump (600 lb.) used for treating purposes. Steam coils carried on the inside of the cylinders through which all exhaust steam passes serve to heat the creosote.

Each cylinder is supplied with oil sprinkling or spraying apparatus consisting of a main pipe, 2 in. in diameter, running the full length of the cylinders with smaller pipes leading into the cylinders to spray the creosote over the ties. The creosote for the plant is furnished in tank cars, which are spotted beyond the cylinder car, and which, with little trouble, can be connected up with the pumping apparatus on the treating car.

The cylinders are 4 ft. in diameter and 63 ft. long, or sufficient to admit seven tram cars with their loads, which average 100 ties. Running to capacity, the outfit is capable of treating 100 ties per hour.

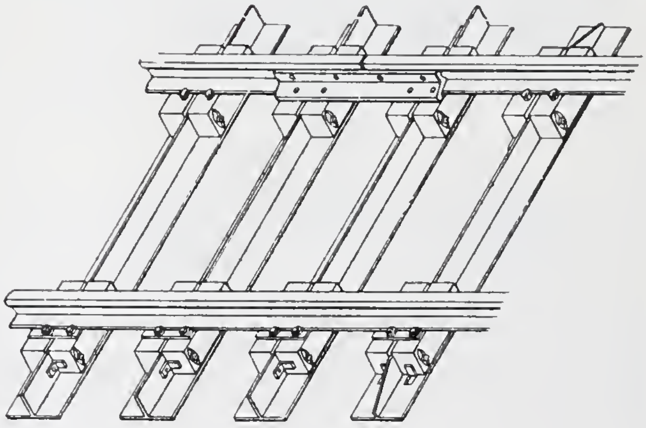
Under normal conditions the force employed consists of two men on the treating car, one to run the pumps and one to open and shut the doors of the cylinders, three men on the adzing and boring car, including an engineman, a fireman and an operator at the adzing and boring machine, and eight laborers. The engineer is in charge of operations, including general repairs, and supervises the labor forces.

In operation the ties are conveyed from the ground or piles to the adzing machine, where they are shaped for tie plates, after which they pass on to the boring machine and then out to the gravity roll conveyor leading to the tram cars ready for introduction into the cylinders for treatment. When in use along the right of way the operation is so planned that a car containing untreated ties is spotted at the adzing car and the ties are unloaded on to the conveyor. The empty car may then be shifted slightly ahead to the proper position for receiving the ties as they are discharged from the cylinder. As noted above, however, the track arrangement on the cars permits the varying of this cycle to meet different conditions.

Experience of C. & A. R. R. With Steel Ties

In a hearing conducted recently by the committee on interstate and foreign commerce of the House of Representatives, officials of several railroads testified as to their experience with steel ties. For the Chicago & Alton R. R., Chief Engineer H. T. Douglas, Jr., told of experience with 306 Peerless steel ties in the main tracks of that road at 22d St. and Stewart Ave., Chicago. A perspective drawing of this tie, reproduced from the Railway Review is shown herewith. Other information taken from the same source is as follows:

The design of the tie is very simple, consisting in a steel T-shape 8 ft. long, 12 in. wide on base and 5 in. deep. To take the bearing of the rail there are two treated oak blocks, each 5½ in. wide, 6 in. deep and 18 in. long to which the rail is spiked in the ordinary manner; if desired, a tie plate may be used. What is equally important is the fact that, supported in this manner, the rails are insulated from the metallic portions of the tie, so that the operation of track circuits is not disturbed.



Peerless Steel Ties.

This matter of insulation of the rails has been a principal difficulty in adapting numerous designs of steel and reinforced concrete ties to main-line track, one source of trouble being the breaking down of specially prepared insulating material under pressure of traffic and through deterioration from the weather. The method here used is essentially the same as that in universal track construction, the rails being spiked to the wood blocks after the usual manner of fastening to wooden ties. The two bearing blocks at each rail seat are securely bolted together through the web of the steel shape.

The ties, being broad of base, are spaced 14 to the 33-ft. rail, and the ballast is filled in to the tops of the same. The design is such that the tie possesses the desired strength and rigidity and the bearing blocks are held securely in place. In the line drawing illustration two patterns of tie are shown. With those at the left the bearing blocks are held to gage by means of clips bolted to the web of the tie, and the web is run full height all the way out to the end of the tie. A modification of this design is seen with the ties lying adjacent and to the right. Here the ends of the tie web are cut down to a slope and the bearing blocks are held to gage by tongues of metal stamped up from the base of the tie. A third design is where there is a reduction in the width of the base of the tie at the central portion of the same, the idea being to throw the principal bearing to the rail seats and ends of the tie, and in this way eliminate a tendency to center binding. These ties have been in service 3½ years, with good satisfaction. They were designed and supplied by the Tri-City Steel Co. of St. Louis.

The "Warfield" Plan for Railroad Control

Among the various plans proposed for the administration of the railroads when the government relinquishes its present control, is one which has a very formidable backing. It is sponsored by the National Association of Owners of Railroad Securities, and is known as the "Warfield" Plan. This association, through its president, Mr. S. Davies Warfield, has presented a memorial to Congress, outlining its plan. This memorial is "by or on behalf of fifty million American citizens owning or directly interested in railroad securities, including over nine million savings depositors in the mutual savings banks of the country, the thirty-three million citizens who own forty-six million policies of insurance on their lives, and the millions of others whose investments in national and state banks and trust companies, fire, marine, and surety companies, largely represent railroad securities; also universities, colleges, trust estates and individual investors."

A very brief summary of the important points in this memorial is as follows:

It is not believed that merely enlarging the powers of the Interstate Commerce Commission will protect the financial structure of the railroads, their credit, or invite further investments in their securities.

No industry can survive or invite additional capital, which as a whole does not earn a reasonable return upon its investment. The Supreme Court of the United States has just asserted (Lincoln Gas case) that any system of regulation which forces earnings of a municipal public utility below 6 per cent would be confiscatory and unconstitutional.

The Congress of the United States has, under the Commerce clause, imposed a system of regulation upon the railroads which has stripped the individual railroad of the constitutional right of an adequate return and has depressed the return upon the nation's railroad investment, as a whole, to 5.22 per cent for the 3-year period, 1915-17, dropping from 5.35 per cent in 1917 to 3.71 per cent in 1918 and running less than 2 per cent in 1919.

The conviction is expressed that the strangulation of the railroads can be prevented only through a mandate to the Interstate Commerce Commission which shall require that the rate level be adjusted so as to produce the minimum primary distributable return of not less than 6 per cent upon the present investment in the railroads, in the aggregate, operating in each of the three classification territories of the country, and that a reasonable proportion of the earnings beyond that primary return shall be retained by the railroad earning it, as incentive to efficiency and improvement in service, the balance to be disposed of in the public interest.

If rates are adjusted to the level of 6 per cent on the property investment in the railroads devoted to public use, each railroad would receive on its individual property investment only such proportion of 6 per cent (allowed on the combined property investment in the railroads grouped for the purpose of computation) to which its efficiency in operation and circumstances would entitle it. Since the property investment accounts of the railroads do not necessarily reflect the amount of securities issued by them, the primary return of 6 per cent would not limit dividends necessarily to that figure.

Mr. Warfield, in a hearing before the House Committee on Interstate and Foreign Commerce on the details of his plan, states that this plan of the association as embodied in the memorial, has signers in every state in the union and in every urban community; that they include 5,000 investing institutions, savings banks, life insurance companies, trust companies, etc., 16 business organizations such as boards of trade and chambers of commerce, as well as several thousand shippers and individual investors, thereby making it a joint appeal of owners and users of railroads.

Under the Warfield plan it is suggested that there be six Regional Commerce Commissions to correspond with the six rate-making regions to assist the present Interstate Commerce Commission and to act as Boards of Conciliation in the matter of wages.

It is claimed that the basic principle to be met in any legislation for the railroads must rest on the limitation of excess earnings. Everyone familiar with railroad operations knows that it would be impossible to make rates to suit the needs of each individual railroad of the country. Further, it is well known that if rates are made that will give sufficient revenue to permit the proper performance of service by the great bulk of railroads," this will give what is considered too much money to the more prosperous and favorably situated roads and the result has been that adequate facilities and service have not always been given the public.

Continuing his testimony Mr. Warfield states that his association advocates the organization of the National Railway Association with trustees composed of the Interstate Commerce Commissioners and representatives of the railroads selected from various sections of the country, the commissioners being the majority. This board of trustees would have the decision of questions relating to consolidation of railroad properties and joint use of terminal and other facilities. If such a board were in existence today it would have been the means of financing the equipment of the roads. Under this plan the railroads would only be required to own equipment for their average business, using the equipment of the association for extraordinary demands.

Dirt Moving With Tractor Drawn Wheeled Scrapers

One of the latest developments in the earth moving field is the use of tractors for hauling wheeled scrapers. The William Dunbar Co., Cleveland, O., is successfully employing outfits of this kind for grading around industrial plants and for foundation work. On one of its recent jobs, involving the excavation of a basement 12 ft. deep and 200 ft. across with a maximum haul of about 200 ft., this company found that one No. 2½ Western wheeled scraper and a 1 man 12 hp. Cleveland "Cletrac" tractor could move as much dirt as three team-hauled wheeled scrapers. A portion of the excavation from the basement was removed in team drawn dump wagons. In this case the tractor was used in place of snatch teams for helping the load out of the pit. The Dunbar Co. also employs its tractor in hauling dump wagons.

Tractor Wheeled Scraper Outfit on Foundation Work

Fellowships in Highway Engineering, University of Michigan.—The Detroit Edison Co. has renewed a fellowship suspended during the war. This fellowship pays the holder $500 per year with an allowance of $100 for expenses. It will be continued for the years 1919-1920 and 1920-1921. The investigation will be the subject of moderate cost country roads. R. D. Chapin of Detroit, President of the Hudson Motor Car Co., also has renewed the fellowship given by him prior to the war. This fellowship is offered to provide for the study of hard surface roads and pavements. It pays the sum of $[illegible] to the holder, with an allowance of $100 for expenses. It is available for the year 1919-1920. Appointments of 1919-1920 Fellows have not been made. All candidates applying up to Oct. 10th will be considered. A Fellow must have a bachelor's degree in civil engineering from a college of recognized standing. He must enroll as a candidate for the degree of master of science in engineering and be in residence at the university for eight months.

Making Explosives Safe

Danger in the handling of explosives is largely a matter of degree. Rare, indeed, are the explosives accidents which cannot be prevented by proper care. The precautions that should be taken are outlined by Mr. C. B. Willis in an article in the September Du Pont Magazine, from which the matter following is abstracted.

Dynamite Storage Magazine.—The character of the building in which the explosives are to be stored is, of course, a fundamental element in what might be called "static safety" in explosives work. The old idea of constructing a massive building of heavy walls for explosives storage has been found to be mistaken. Indeed, experiments have proven that the lighter a building can be constructed—with due regard, of course, to stability—the better it is for explosives storage. The logic of this is apparent when it is remembered that the building would receive the maximum force of any explosion and that the greatest menace to life and property in an explosion is flying material. Consequently, a building constructed in such a manner as to reduce to a minimum the size and number of missiles is the ideal from the safety standpoint.

The best modern practice in explosives storage calls for buildings of brick, hollow tile or wood, constructed with a double wall. The interstices are filled with dry sand or a weak mortar cement. Wooden buildings, of course, must be covered with sheet iron to protect against fires. Great care must be exercised to see that all weeds and grass in the vicinity of the magazine are kept cut. This precaution is necessary to combat the danger of "grass fires" during the late fall and winter months.

As nearly all explosives are susceptible to moisture, the magazine should be so located that perfect drainage can be secured, and the building so constructed that perfect ventilation is obtained.

Where it is possible to do so, magazines should be erected on a site protected by higher ground or heavy timber and remote from any residences. If this is not practicable and if dwellings are near the magazine, artificial protective barriers must be built. Such barriers are usually constructed of heavy timbers firmly set up. The side of the barrier away from the magazine is terraced with dirt to the top of the barricade. As it is decidedly unsafe to store caps or electric caps with dynamite, it is absolutely necessary to have separate magazines for the two classes of material. Such buildings should be at least 100 ft. apart.

As to the distance to be allowed between a magazine and inhabited dwellings, the Bureau of Mines recommends that a magazine to contain a maximum of 20,000 lb. should be 1,055 ft. from dwellings, if the magazine is barricaded, and double that distance if not thus protected. In the case of a magazine to contain 40,000 lb. the distance should be 1,340 ft. for barricaded buildings, and double that distance for non-barricaded buildings.

The number of employes in dynamite magazines should be limited. No one except the foreman or blaster should have access to the keys of the magazines. The necessary rules for the safe handling of explosives should be prominently displayed in each magazine for the guidance of employes. The Du Pont Company will furnish copies of these rules printed on cloth.

Care of Magazines and Contents.—Whenever it becomes necessary to make repairs to the interior of a magazine, all the explosives should be removed from the building and stored where they will be kept dry. If black powder has been stored, the magazine floor should be washed before starting work; if dynamite has been stored, the floor should be examined carefully for grease spots. If any are found, it is possible that they were caused by nitroglycerin which has leaked out of its container. As a precaution against this possibility, the suspected spots should be neutralized by applying to them generously, with a broom, brush or mop, a solution consisting of one half gallon of water, one half gallon of wood alcohol, and two pounds of sodium sulphide. If repairs are to be made to the outside of the building and are likely to cause sparks, the explosives should be removed before the work is started.

The condition of the explosives stored is another important factor. High explosives consist of sensitive chemicals absorbed in a non-explosive base. The purpose of this base is to separate the particles of the chemicals and make them safer to handle and more adaptable to commercial purposes. Under improper storage or continued storage for long periods, the liquid ingredients of the dynamite will leak out of the base and be absorbed by the box. Continued storage of explosives in this condition will eventually cause the liquid to leak out on the floor. Explosives in such condition are a serious menace and should be destroyed without delay.

To accomplish this safely, the explosives should be removed to a safe distance from the magazine and taken out of the boxes. Then the cartridges should be split open and spread on the ground so as to make a continuous train. In order to insure proper burning of the powder, it should be saturated with coal oil. Fire should then be applied at one end of the line. The empty boxes are really more dangerous than the deteriorated dynamite, and even greater care must be used in disposing of them. The best way is to pile up the boxes, a few at a time, and saturate them with oil. Fire may be applied by the use of shavings, straw or paper. The reason for the use of such mediums in igniting the bonfire is that the person who does the work should be at a safe distance before the fire reaches the boxes. Where considerable quantities of spoiled explosives are to be destroyed, it is wise to call upon the manufacturer for assistance and advice.

A rather common practice is to allow the workmen to take the empty explosives boxes home with them This should not be allowed. All boxes should be destroyed. Another unsafe practice in some magazines is to allow partly filled boxes to remain open. In this state the explosives absorb moisture more readily and also present an easy target for stray sparks.

Loading Bore Holes.—The first consideration in loading is the preparation of the primer. This consists in placing the cap and fuse or electric blasting cap in the cartridge of dynamite that is to be used for exploding the main charge. This work should be intrusted to none but a careful and competent man. A small house where this work can be done at a distance from the magazines, is desirable. Under no circumstances should it be done in the storage magazine or thawing house.

In loading holes of small diameter and, in rare instances, larger holes made by a well drill, blasters sometimes chamber or "spring" the holes by firing small charges of dynamite in the bottom without tamping. In almost every instance where this is done, more than one springing shot must be made before the chamber is large enough. A charge of dynamite so fired makes the stone very hot, and sometimes the blaster fails to allow sufficient time for the hole to cool off before attempting to load another springing shot or even the full load. It is quite possible to cause a premature explosion under such conditions.

Considerable trouble is sometimes encountered in loading well drill holes, through the dropping of loose stones on the tamping block. These stones often become wedged between the block and the side of the hole. There is danger in this, especially where the dynamite cartridges have been split open and the loose powder poured down the holes. Such situations may be met in various ways. Many blasters feel that the safest and surest procedure, in such cases, is to lower another loading block and drive the wedged one down. With a view to avoiding this annoyance entirely, some loaders use funnel-shaped zinc tubes of the same diameter as the bore hole.

In loading large blasts, especially in well drilled holes, it is customary to insert at least two electric blasting caps, one near the bottom and the other near the top. To overcome the possibility of a misfire and its attendant dangers, most blasters insert an extra electric blasting cap, but do not connect it with the blasting machine. The idea of this procedure is that should the wires from both the other caps be cut, there is still a possibility that the third one may escape undamaged; then, by connecting that one to the blasting machine, the hole can be exploded.

There is nothing more provoking to the operator than, after a shot is connected and the workmen at a safe distance, to have the shot fail to fire. In the majority of such cases, improper connections of the electric equipment are to blame. In making connections for electric blasting, care should be taken that all wires to be connected are bright and clean. If considerable water is present, connections should be protected with tape. If the connections are not taped, they should not be permitted to rest on a bare stone or in water, as a short circuit may result.

The wires leading from the shot to the blasting machine or power circuit should be kept in good condition and dry. Such wires, when they come from the factory, are protected with heavy insulation. If this insulation be broken, there is danger of the circuit's grounding. Sometimes the trouble is due to a cut wire in a bore hole. For detecting such conditions before the shot is attempted, the blaster can quickly determine by means of a galvanometer, whether or not there is trouble on the circuit and, if so, just where the trouble is. It is both dangerous and worrisome to have some shots go off and others fail. Most frequently, under such circumstances, those holes that do fire shake up the stone to such an extent that it is practically impossible to fire those that missed. Then the operator is put to the trouble, expense and danger of digging out around a charge of unexploded dynamite.

Fuse is another important element in safety. The fuse manufacturers make fuse with varying burning speed. A certain brand of fuse will burn at a certain speed, and another brand may burn faster or slower. Therefore, it is wise for the operator to confine his purchases to one good brand and grade.

The "human equation" is of extreme importance in explosives work. It is difficult to get men to exercise proper caution in lighting charges. After they have been at the work for some time without getting hurt, they are inclined to take chances in lighting too many fuses at a time. In training a new man in the use of explosives, it is, therefore, necessary, first, to remove his fear of them, and later, after he has used them for a short time, to go back and teach him to be afraid of, or at least, to respect explosives. To those who are making constant use of explosives, a reliable and careful powder man is an almost invaluable asset both to purse and peace of mind.

Labor Unrest and Some Remedies*

By CHARLES PIEZ

President Link-Belt Co., Chicago.

If the Plumb plan is any gauge, then nationalizing the railroads, nationalizing the mines and the industries does not mean government ownership and operation in the ordinary acceptance of the word, but purchase out of public funds, with an absolute surrender on the part of the public of every form of control and direction to the employes, without power of revocation. I am referring to the Plumb plan as a symptom rather than as a possibility, but it shows the character of the malady. And when organized employes of the railroads tie up traffic in four states, and subject the public to loss and discomfort merely for the purpose of influencing a decision in a trolley strike with which the Railroad administration was in nowise affiliated, it indicates that popular government, if its representatives lack courage, can be absolutely under the domination of an organized, selfish and unscrupulous minority.

I commend the President of the United States and the Railroad Administration highly for the sound and courageous attitude taken in the southwestern railroad strike. But I regret that his position was coupled with a promise to raise wages if the Administration's efforts to reduce the cost of living proved futile. If the high cost of living is due to profiteering by merchants, manufacturers, employes, farmers or workers, then the government ought to be able to reduce it. But if, as is more likely, investigation proves that the high cost of living is due to economic causes beyond the control of this nation, to world-wide reduction of output to a point far below present world demands, then it will be unwise, to say the least, to meet the situation by a general wage increase, unless that increase is justified by a corresponding increase in effort and output. For if our premise is correct, then the only way out of the difficulty is to produce more and consume less. Nothing else will do.

I am opposed to government by coercion, by threat and intimidation, because it is subversive of the popular will. I am opposed to the general strike, that un-American instrument of labor oppression, because it attempts to win its point, not by its merit, but by putting an entire community to such inconvenience, trouble and loss that the public will insist on a settlement rather than submit to further privation.

Certainly such procedure has no place in a democracy and it will have no place if Mayor Hanson's methods at Seattle be used as a precedent.

New Terms of Foreign Origin—New terms have crept into our language that carry with them a threat and a menace—Bolshevism, the dictatorship of the proletariat, the direct actionist, the Soviet, the solidarity of labor. They are of foreign origin and receive but scant hospitality from American-born workmen. I have no fear that Bolshevism will take root here, but I do feel that even the American born workman subordinates himself too readily to the domination of his union leaders, and that he is working on the theory that loyalty to the union, and not loyalty to the public interest, is his first duty.

The union is supposed to be a form of democracy controlled by the will of the majority; but there are few cases, indeed, in which the free and unrestricted views of the majority prevail. Meetings are subject to the same plays and tricks as political meetings, and rumors of packed meetings, coercion, intimidation, and other misuses of power are by no means rare.

The meeting hall of the Boilermakers' Union at Seattle is reported to hold 900 men. The membership of this union is said to be 15,000. The vote to strike was taken last January at a late hour by men present in the hall, so that a majority of approximately 6 per cent of the membership determined the policy and action of the other 94 per cent. And such is the loyalty, or the habit, of the members, that the 94 per cent accepted the vote as binding, although private polls of several large groups showed a large majority against the strike. I believe there is no doubt that the Seattle strike was decided upon and enforced by a minority; that it was not the result of free registration of the will of the majority, after a full discussion. Members of unions will learn sooner or later that it is through such action as that that confidence in their responsibility to carry out an agreement is lost, and that unionization of industrial processes is looked upon as a step toward business demoralization and ruin, by many employers.

It is to the interest of the sane rank and file of the unions to see to it that pledges and agreements be kept in both spirit and letter; that methods and practices like systematic reduction of output be discarded, so that public sympathy, which heretofore has been unstintingly given to the aims and aspirations of labor organizations be not forfeited through wrong and harmful methods.

More Pay, Less Work—The unsettled conditions incident to the war and the general desire on the part of labor to get a large share of the profits of industry, have resulted in some marked reductions of output. I have it on good authority, in two of the large cities of the country, and we may assume this condition to be fairly general, that while formerly from 1,500 to 2,500 common brick laid in the wall per day, depending upon the kind of work engaged in, represented a fair day's work for a bricklayer, today it is impossible to obtain more than from 700 to 1,000 brick laid under the same conditions. While this reduction has taken place over a number of years the heaviest shrinkage in output has occurred during the past year and a half. And this reduction in efficiency is by no means confined to bricklayers, but is characteristic of some of the other building trades as well.

The complete unionization of the clothing industry is being accompanied by an abolition of the piece rate system and by a reduction in the daily output per worker as well. Is it not timely to suggest a national investigation to determine to what extent a reduction of average output has tended to raise the price of certain commodities?

With such evidence as this before us, can we doubt for a moment that the insistence on the continuance of the "open shop" principle in industry is made in the public interest?

Greater production, greater thrift and frugality are the most effective factors in reducing prices, but increased production cannot be achieved unless wages be based on output instead of on hours worked.

The last two years have witnessed a wide extension of the 8 hour day, and if that has carried with it a corresponding reduction in output, and a proportionate increase in pay per hour, a very considerable increase in cost of commodities is accounted for.

Wages Based on Output—I recognize, of course, that the objection of certain unions to piece work is well justified because of past abuses of this method of wage payment but there can be no question of the fairness and soundness of paying a man for the amount of work turned out, providing the unit or piece rate of compensation is fairly and equitably determined, and its permanency guaranteed. To meet the present urgent demand for increased production we can hardly leave it to the individual operator to determine what output a fair day's work shall represent; for we will sink inevitably to the capacity of the least experienced and least ambitious, for our standard.

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*From an address at "Our Country First Conference" held Sept. 9 under the auspices of the Illinois Manufacturers' Association.

Wages based on output, under safeguards that will correct and prevent abuses, should be accepted by organized labor in industries where this practice has been discarded.

There is no doubt that a considerable part of industrial unrest, and its companion, industrial shirking, grew out of the exaggerated notions of profits which the intense industrial activity during the war was supposed to yield. No account was, of course, taken of the outlay for buildings and special equipment which had to be paid for out of profits, nor of the heavy inroads which federal taxes made on the gross return. During the Seattle strike, agitators stated in open meetings that the largest shipyard in Seattle was earning $60 per man per day, out of which the man received $6. The statement was, I was told, widely accepted as representing the exact situation, and yet the facts were these: The yard employed 15,000 men, who, according to the statement, earned for the yard the small sum of $810,000 profit per day, or $250,000,000 per year. This represented over four times the total annual output of the yard, and more than two and a half times the value of the contracts held by it. Publicity of the facts is not a bad remedy to apply in such a case.

Another and not an inconsiderable part of present-day unrest is due to the nonfulfillment of expectations growing out of the winning of the war. It was predicted that victory would bring in a new order of things, new social conditions, new relations between employers and employes in industry. Statements of this character were largely idealistic, and referred to an extension of rights and privileges to the downtrodden races of Europe, rather than to any promise of an increase in material advantages to our own citizens. But many people built high hopes on this rhetorical groundwork, and there is naturally keen disappointment that the armistice was not followed by an immediate improvement in the status and income of the individual. This was to be expected. To change from the excitement, the intense interest and the stimulus of war to the commonplace and comparatively humdrum conditions of peace, required a mental readjustment of our people that could not be accomplished without manifestations of discontent and distrust. It will take time to complete the change, but in the meantime we have a much more critical industrial body to placate and satisfy, and we must look for a remedy to allay unrest and convince the workers they are receiving their fair share of the profits of industry.

Remedies for Allaying Unrest—Let us admit in the first place that the industrial problem is a complicated one that will yield to no particular formula, and that where there are so many suggested remedies there is probably no single and specify remedy.

The democratization of industry is glibly spoken of as one of the remedies, and the interpretation placed on this phrase ranges from the establishment of shop committees with authority in matters affecting the employment relations, to the complete control of the industry by the employes. I am not at all impressed with the idea that by democratizing industry we can solve labor difficulties and maintain the health and prosperity of the enterprise as well.

Competitive industry isn't a social or charitable affair, it is a conflict, and leadership is required to bring success. Just as the nation realized that arbitrary power must be concentrated in the hands of the President of the United States to make the nation's resources and facilities effective in time of war, so to keep industry strong and sound it is necessary to place in the hands of the individual that runs it positive and complete authority. No competitive business that I know of was ever successfully and profitably run by an executive committee or other form of divided authority. Democratization that goes so far as to inject a foreign and discordant element into the management of an industry, that reduces and splits up the authority of the executive (and I believe those to be the aims of the proponents of this suggestion), will either kill industry or reduce it to so moribund a condition that it will have to be kept alive at the public expense.

The prosperity of the country, the opportunities for employment, depend on keeping industry in a strong, healthy shape. Co-operative production, a form of completely democratized indusiry, has been demonstrated a failure. Governmental operation, another form of the same kind of management, has certainly not proved a success. Let us, therefore, resist any experiment or tendencies that will weaken and ultimately destroy the vigor and success of American industry.

Profit Sharing as a Means for Improving Employment Relationship—Another suggestion to improve the employment relationship has been profit sharing, and new experiments are being tried at every hand. I am highly interested in the results, but as a means of allaying unrest and satisfying the worker, I am afraid most of these experiments are foredoomed to failure. The schemes that succeed will succeed because of the personality of the man behind them, and not because of the merit of the schemes. Profit sharing as it is usually applied, involves payment to the deserving and the undeserving; to the ambitious, energetic, useful employe, and to the laggard who succeeds in just getting by. It is apt to result, therefore, in general dissatisfaction, and a lowering of the standard of efficiency. Many plans have been tried, but a small fraction survive. The profits of the average industry are rarely sufficient to make the amount distributed to the individual large enough to stimulate and retain his interest, and only exceptional industries like that of Mr. Ford can continue to make really effective distribution. I like Mr. Ford's plan, for it consists in paying high wages and insisting that the employes earn them. My own conviction is that the best system for profit sharing consists in the opportunity for earning liberal wages for a standard amount of work performed, and that extra effort and output or extra quality ought to entitle the man to earn wages in considerable excess of the prevailing rates. This gives the man an immediate additional return on work that is within his own control, and does not force him to wait until the end of the year for an indefinite share in an uncertain profit.

Labor as Part Owner of a Business—The idea of taking labor into partnership is offered as another remedy. It sounds alluring, but, like profit sharing, is another one of those schemes it is difficult to make workable and permanently effective. In the first place, the average industry, with an investment of, say, $2,000 per employe, rarely earns in normal times as much as $1 per employe per day. When the return for capital invested is set aside and provision is made for necessary additions and extensions, there is little or no cash to divide, and there is general disappointment among the partners. If any division is made, it must be made in stock, or its equivalent—it can't be made in cash.

Interest in the ownership of a business undoubtedly has a steadying, stabilizing effect, but this interest must be earned through thrift and sacrifice, and not demanded as a right. I will not admit that the success of the industry I am at the head of has been gained at the expense of our wage-earners, that its continued growth has been due wholly to them, and that its capital and surplus have been accumulated by withholding from the men a part of their just earnings.

Our industry, like many other American industries, started through the ingenuity, inventivenes and business sagacity of men who entered a new and untried field. It grew through the thrift and enery of these same men. They weathered its storms, stayed with it through its discouragements, and kept it in the van by the constant addition of new and useful developments, and by the addition of capital for the use of which they mortgaged their future. There are no wrongs to be righted, no redress to make, and no moral justification for turning over title to part of our business to our present wage-earners. I say this in full recognition of the splendid and valuable services rendered by some of our employes, because I feel that full compensation was given, not only for daily tasks performed, but for suggestions and extra services that were useful to the corporation.

And yet I am strongly convinced that a real pecuniary interest by the employes in an industry is a good thing, provided that interest is paid for. Partnership must carry with it a sense of responsibility in the pecuniary success of the venture, and cannot be helpful or effective if it represents an association in which one partner is purely interested in securing all he can for himself, without thought of the continued strength and success of the venture. I am in favor of opening up the opportunity for acquiring a stock interest in an industry, to every workman whose length and character of service justifies it, and who has the nerve to assume the responsibility to pay for that interest in cash. And when the stock acquired by workmen and employes reached a proper volume, I would gladly welcome a representative of their choosing, as a member of the board of directors.

Representation on the board, except on the basis of stock interest, would not and could not bring about the purpose which the proponents of this suggestion have in mind, but would impair, if not ultimately destroy, the very life of the industry.

I believe that the biggest problem industrial management faces today is the labor and production problem; that it transcends in importance the sales and the financial problems, and that it is worthy of the exclusive and direct attention of the chief executive.

Heat Treatment of Track Materials

Mr. C. B. Bronson, in a paper presented at the June meeting of the New York Chapter of the American Steel Treaters' Society gives a résumé of some of the later developments in the treatment of steel. The following notes are taken from his paper:

The funamental basis for successful heat treatment is sound steel. This implies not only structural soundness and freedom from blow holes, pipes and inclusions, but chemical and physical homogeneity as well. Heat treatment of unsound steel probably does more harm than good, for even the best steel is put to a severe test during the quenching operation, while unsound or segregated metal may be easily fractured or weakened.

Probably for general service requirements, where properly designed sections are used, it will be a long time before the present efficient plain carbon basic open hearth steel rails will be replaced as standard for most of the roads in this country. Basic open hearth rail, under our present elongation and exhausted ductility test, making it possible to obtain nearly all the ductility due to the chemical composition, is a wonderfully efficient product with a low rate of failure, and moderate rate of wear.

The simplest process for heat treatment of rail steel, of course, is the air-cooling method introduced by one manufacturer. This consists of an air blast blown from numerous small openings in a straight pipe, and directed against the top surface of the rail head; the blast being maintained for about two minutes, after which the rail is allowed to anneal in air.

Patents have been issued to one company covering a combined oil and water treatment, which consists in passing the finished hot rails, head down, into a series of quenching vats so constructed and regulated that the head only is treated in the first oil bath; passing them to the second vat where the head is immersed in water and the web in oil. In the third vat both head and web are in water, which completes the process.

One manufacturer found it necessary to redesign the standard section to heat-treat successfully rails made of Mayari steel. A section, similar to the present "B" type 100-lb. rail, was used as a basis, and to this was added 21 lb. by providing very generous fillets between head, web and base, and also increasing the thickness of the latter.

The only alloy heat-treated rails which have been made and purchased in large numbers are manganese steel rails. Those of early manufacture developed breakages with great frequency, but this difficulty has since been overcome, as a number of changes in manufacture were introduced. The New York Central purchased several hundred tons of these rails four years ago, and since that time they have carried over 100,000,000 tons of traffic without one failure and at a remarkably low rate of wear, an exceptionally good record. From present indications, they should outlast plain carbon steel rails in the ratio of 10 to 1.

The wonderful toughness inherent in manganese steel makes its use particularly inviting for rails on curves. Our present practice is to place them on the high side of curves with plain carbon rails opposite, generally reversed, curve worn high rails, which make the best combination. The susceptibility to flow prohibits their use on the low side of curves, especially where the tendency to [illegible] flatten under the wheels of present improper contour is very great.

The 6 in., 105-lb. Dudley type rail is the only one which the New York Central R. R. has had rolled in manganese steel. This is a broad head, stiff section possessing high mechanical properties which are necessary when using metal with such low elastic limits. Any road contemplating the purchase of manganese rails is advised against ordering them rolled in light sections, for the combination of the low elastic limit and deficient mechanical properties make it easy for them to acquire permanent sets in service, creating rough riding track, and may eventually be the cause of derailments. Manganese rails injured by truck derailments from causes other than roughness of track, are badly bent out of shape, although they remain unbroken. It is necessary to scrap the rails, as they cannot be straightened by any known method.

The composition specified for rail steel is as follows:

Carbon	1.00 to 1.35	Phosphorus max.	[illegible]
Manganese	10.50 to 15.00	Sulphur	Not specified

Two heat-treated track materials that are purchased in large quantities are rail splice bars and track bolts. Splice bars are made to the following chemical and physical requirements:

Carbon	0.45 to 0.55	Elastic limit	[illegible]
Manganese	0.30 to 0.50	Elong. in 2 in.	12 per cent [illegible]
Phosphorus, max.	[illegible]		

In manufacture, the bars are sheared to length, reheated to about 800° C., hot punched and quenched at 700° C. or over, then subsequently reheated or withdrawn from the oil bath for tempering. The high elastic limits obtained place them on the same level as rail steel so far as physical strength is concerned, and increase their resistance against permanent sets, and sagging at the joints.

Track bolts when heat-treated show elastic limits of 70,000 lb. and over when made of about 0.30 carbon steel. These high limits provide additional strength, against stretching when tightened with the trackman's wrench, and becoming loose due to the transmission of stress at the rail ends and the impacts from wheel loads. The usual process for heat treating consists in rolling the threads hot, then allowing the bolts to drop into a bath of oil and finally discharged into a hopper from an endless chain. Heat-treated bolts are in extensive use and giving satisfactory service.

Logging Locomotive Transported on Truck and Trailer

The Clipper Shingle Co. of Bellingham, Wash., found it necessary to move a logging locomotive from one of its timber claims to another between which there was no connecting railroad. With the aid of a derrick the locomotive was lifted from its trucks, and mounted upon a 10-ton Garford tractor and trailer, as shown in the illustration, and hauled over rough forest roads to the scene of its future operations.

10-Ton Tractor Transporting Locomotive.

MANAGEMENT AND OFFICE SYSTEM

This section is published twice a month: (1) In the Waterworks and Hydraulic Monthly issue, and (2) in the Railway and Excavation Monthly issue. It covers what may be broadly termed "management engineering" as applied in the civil engineering and construction fields.

How the American Railway Express Co. Secures Greater Service from Its Motor Trucks

At the present time the seven or eight separate express companies merged into the American Railway Express Co. are garaging and maintaining 3,313 motor vehicles—the largest fleet in the world. Of these vehicles 1,940 are of the gasoline type, and 1,373 of the electric type, ranging from the 5-ton freight carrying truck to the single passenger motor car. The fleet is made up of 53 different makes of vehicles. The system for taking care of this plant is described by Mr. B. K. Rhoads, Assistant General Superintendent of the American Railway Express Co., in the August 100% Magazine, from which we quote as follows:

About 12 years ago the then various railroad express companies decided that motor trucks had become sufficiently reliable as freight carrying vehicles to be employed in their business, and purchased a small number for use at a few of the larger eastern cities.

Four years later the experience of the company with which I was then connected lead them to instruct their operating department managers to employ motor trucks throughout the country in the large cities, or elsewhere if conditions warranted, and whenever additional vehicles were necessary at these offices, agents were expected to requisition motor trucks instead of horses and wagons. This led to the placing of one or two motor trucks here and there throughout the entire United States in cities of moderate size, and in greater numbers in the larger cities.

In a short time this policy was changed, and the trucks scattered about in small numbers were concentrated, and either added to the fleets in the large cities or placed at smaller points in sufficient number to entirely replace the horses and wagons.

It was not an operating condition that brought about this change; it was maintenance and garaging conditions that compelled it.

At offices where we had but one or two trucks we could not afford to employ competent inspectors and repairmen; our drivers were not experienced in such duties, and the garage owners or operators did not or could not satisfactorily meet the situation. Regular traveling inspectors were not considered economical or entirely satisfactory.

Therefore we concentrated the motor vehicles where we could afford to employ our own inspectors, garagemen and repairmen. As fast as the trucks reached their first overhaul period we made permanent exchanges of newly overhauled and painted vehicles from the offices where we maintained our own shops for other trucks needing overhaul in the nearby cities, and thus we concentrated our overhauling so that the volume of work enabled us to employ competent men, specialize their work, and increase their efficiency.

Co-operation Between Operating and Maintenance Departments.—Anyone associated with maintenance of motor vehicles realizes the value of close co-operation of the operating and maintenance forces. The driver is the first one to observe faults that need correction and if we can get and keep him interested in his work, he will by practice soon be able to intelligently describe his troubles in writing for the attention of the repairman.

When we first began the operation of motor vehicles double shifting was permitted. The result was disorder and inefficiency in operation, inspection and maintenance.

Drivers became dissatisfied over their failure to secure the same vehicle daily, lost interest in careful and economical handling of the equipment and in the reporting of mechanical faults; it was no longer possible to have one inspector cover the same 10 to 12 trucks, and he lost interest and could not properly follow up his work; repairmen lost interest and became negligent because it was impossible for the inspectors to check them up, give them full credit for good work or to criticize them for poor work, so that in a comparatively short time the double shifting was discontinued and was not permitted again until the unusual conditions at the outbreak of the war forced us out of our chosen path

With the motor vehicle equipment confined to single shifts, each unit in the hands of a regular driver and relief equipment on hand to the extent of 6 per cent of the vehicles needed for daily use, there was marked improvement in the inspection, maintenance and operation, and a satisfactory continuity of service was easily maintained so that during peak periods at various seasons of the year it was possible for several months at a time to operate as high as 97 per cent or 98 per cent of the motor vehicles.

At all except the largest offices our garage and repair shop superintendents also hire and fire the drivers. The operating department really should control this class of men, but importance of the maintenance feature is conceded by all of us, and therefore the drivers are controlled by those responsible for the maintenance and inspection.

At the larger points where the plan just referred to cannot be followed, we try to maintain very close co-operation between the supervising heads of the operating and maintenance departments.

In New York City we garage and maintain 1,043 motor vehicles made up of gas and electric street trucks, electric industrial trucks and taxicabs, in seven garages, three overhaul shops and two paint shops. There of these garages are one-story buildings while the others range from three stories to 11, the largest being at 44th St., where the inspection and running repair work is specialized to a greater extent than elsewhere.

Inspection.—In this building doormen record numbers of vehicles and the time they leave, as well as guard the sidewalk crossings to prevent injuries to passersby, and vehicle inspectors here give a superficial examination of the vehicles and their accessories. The same record of numbers and time and a similar examination is made at the incoming door as vehicles return to the garage.

The result of these inspections is transmitted to the inspectors on the various garage floors who thoroughly examine each vehicle after its period of work. The drivers as they reach the garage floors or leave their vehicles are required to enter in a record book maintained for the purpose, any faults they have found with their vehicles. The drivers report, the result of the door inspection and the floor inspection are all taken into account by the running repair foreman in assigning the work of the running repairmen

Repairs.—It is our practice to make carburetor and magneto adjustments and strictly minor running repairs at the various garages on the floors where they are garaged; a vehicle requiring anything more than this is sent to one floor where we maintain a running repair shop.

In this shop more extensive running repairs are attended to, including all pit work and the exchange of worn or broken units for others that have been repaired. This substitution of complete units such as motors, steering units, transmissions and axles is employed to a considerable extent, especially in connection with makes or models of vehicles where the number in service justifies our carrying in our stockroom a supply of such units overhauled and ready for use in an emergency. It enables us to avoid holding vehicles out of service in order that such parts may be taken out, repaired and replaced.

In this connection I call attention to the necessity as we see it of considering the direct bearing that loss of time in operation of a motor vehicle has upon the rate of maintenance cost; that is, if you have proper co-operation between the maintenance and operating departments, a high maintenance cost in one direction may be justified if it results in continuity of service and therefore a lowering of average operating costs.

General Overhaul.—In considering the question of general overhauling or rebuilding of motor vehicles, one must first determine when such work should be done. The close attention we are required to give to inspection and running repairs has made the regular periodical overhaul unnecessary, and the time for such work is determined by the condition of the truck in each case. This plan also enables us to determine usually in advance whether the overhaul is to be partial or complete.

After these preliminary steps, our next consideration is facilities for performing the work. Naturally with such a large and mixed fleet, we must necessarily have a completely equipped machine shop.

The number of overhauls to choose from enables us to select trucks in lots of approximately 50 at a time of the same make and so far as possible the same model, and either purchase or manufacture in advance the parts regularly required. With the exception of the past year or two of very unusual conditions, we have experienced little or no delay in buying from manufacturers or their agents the parts needed.

Our ability to pick a comparatively large number of trucks of the same model and make for overhaul at one time gives us another advantage over many operators, in that it reduces the amount of stock we are obliged to carry throughout the year and makes it necessary to carry certain kinds only immediately preceding overhaul.

Disassembling Inspection.—Next in importance comes the method to be followed in performing this work. Careful preparation in advance so far as material is concerned is of first importance and the first one or two vehicles disassembled are usually a reliable guide to indicate whether our advance preparation has been adequate; that is, where we find extensive wear making complete replacement necessary in the first one or two, the same condition usually obtains throughout the balance of the trucks to be overhauled.

We confine our disassembling work to one floor where a minimum number of experienced men with a sufficient number of helpers has greatly reduced former costs in this branch of the work.

After the disassembling has been completed the parts are cleaned in soda tanks with a minimum loss of time as compared with the former method of scrubbing. Then follows a period of inspection which is highly specialized and is one of the most important steps in the entire overhauling process. Here we require a man acquainted with practically every model of motor vehicle overhauled in his shop to judge from knowledge ripened by experience as to where to draw the line between repairing of old parts and substitution of new ones.

Some years ago I was interested to note that both in our own shops and in outside overhaul shops the total expenses of a complete overhaul were divided approximately on the basis of 60 to 70 per cent labor, and 40 to 30 per cent material, and from a hasty examination of recent records it appears that today, with a much higher cost for both material and labor, these general percentages still obtain.

The importance of this point must be fully appreciated by the man who determines whether an old part may be repaired, knowing that it may not remain usable until the next overhaul period and must therefore be replaced in the meantime, or whether a new part should be substituted, and in this connection he must also have directly in mind the accessibility of any such part in the event that it must be replaced by the running repair department.

This question of various parts requiring repair or replacement between overhaul periods is one to which we require our mechanical superintendents to pay particular attention. Manufacturers as a rule fully appreciate this point but it is also a possible source of increased maintenance cost that cannot be detected by even the closed analysis of monthly reports.

Replacement and Repair of Parts. Immediately after the inspection has been completed in our dissembling room orders are placed for the repair or replacement of parts with the approximate date for their delivery to the assembling room specified.

The repairs are then carried on in separate departments where various branches of the work are assigned to individual experts. Here again we have developed economies that are not ordinarily possible such as slight redesigning of parts or substitution of cheaper for more expensive metals which at the same time satisfactorily meet our requirements.

A large proportion of the total work of our overhaul shop is devoted to the manufacture of parts, this can be carried on continuously so that the over-production during the comparatively slack overhaul periods provide adequate supply for the peak periods in the overhaul work.

We find that a very small proportion of parts cost more to manufacture than to buy from an outside manufacturer. The only cases where we manufacture such parts are emergencies.

We have about nine central points that carry from $10,000 to $125,000 worth of material for distribution to the surrounding territory.

By highly specializing the work of mechanics in our repair shop we have benefited in various directions. Certainly a man performing the same class of work day after day finds it more irksome than a variety of duties, but he is also inclined to develop improvement and call attention to practical means of reducing our costs.

A simple illustration of this point was the recommendation and adoption of a lock washer of a type not commonly known or used, but that developed a remarkable value. A maintenance man can easily realize the effect of such an apparently insignificant detail upon maintenance costs having in mind the excessive vibration motor trucks are subjected to.

The possession of our own welding equipment is also a distinct advantage in various ways. Many parts that are very expensive to replace are built up by the acetylene welding process. I recall one instance where a part costing $9 is commonly repaired by this process at an expense of $1.50. The saving of time necessary for disassembling parts and sending them to outside welders, securing their return and reassembling them is also a very important item.

As an extreme example I cite the case of a 3-ton truck where a cracked cylinder was welded without removing the cylinder from the motor or the motor from the truck. This may be regarded by many welding experts as impossible or at least a doubtful practice, but in not only one but in every case where we have attempted it we have been completely successful.

After repairs or replacement of the various parts have been completed, they are gathered at a definitely scheduled time, which we are generally able to adhere to, upon the assembling floor where the complete truck is prepared for road test and return to service.

Cost of Cleaning Yard Tracks

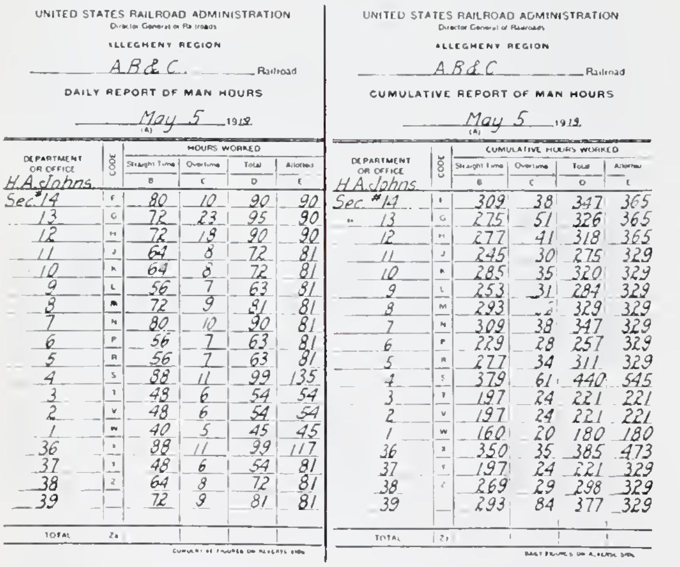
The receiving, classification and advance yard tracks in a freight terminal are generally and uniformly difficult to maintain because of their almost constant use, and in the case of mineral yards because of the great quantity of material spilled and shaken from the cars onto the tracks. Rail and splice materials are never of the best, and add considerably to the wear. Ties are apt to be of inferior size and allowed to remain beyond their useful life limit. Maintenance work is generally done in the form of renewals, but when a particular track absolutely requires attention arrangements are made to obtain the use of it and it is then renewed and practically rebuilt. Ballast is usually of cinder or gravel, which is not difficult to handle, but after a few years' service becomes practically impervious and offers very poor opportunities for drainage. Drainage is usually of the surface type and is seldom adequate, resulting in bad pumping track.

Policing of these yard tracks is difficult and apt to be dangerous. It should be done frequently, but such is unusual, with the result that accumulations are large, necessitating the services of a work train and a large number of men. In most yards the practice is to gather or scrape the dirt into piles in places where it can be reached by a work train. The dirt may be piled in an inter-track space, but it is preferable to locate the dirt piles in an open space if possible. The cost per 1,000 lin. ft. of track covering a single cleaning, including the gathering of the dirt into piles and hauling away by work train, will be about $10. This figure, states Mr. J. B. Baker, Supervisor Pennsylvania R. R., in an article in the Railway Maintenance Engineer, will vary somewhat with the class of yard and kind of dirt, and the annual cost per 1,000 lin. ft. of track of periodic cleaning will be about as follows:

Type of Yard.	Frequency of Cleaning.	Annual Cost Per 1,000 ft. of track.
Classification Yard—		
Merchandise freight	Every six months	$20
Mixed freight	Every four months	35
Mineral freight	Every two months	60

Form for Comparison of Labor Charges

The accompanying illustration, reproduced from the Railway Maintenance Engineer, shows a form devised in the office of the director of the Allegheny region, United States Railroad Administration, for the daily and cumulative tabulation of labor engaged in maintenance of way work. The form was put into effect on the roads in that region on April 1. This report is prepared for the use of supervisory officers in checking the actual labor employed in comparison with that estimated in the monthly budgets, and authorized. On one side is the daily report, while on the reverse side is the cumulative report from the first of the month up to and including the date shown on the first side. By means of this report the supervisors are able to inform themselves daily of the adherence of their forces to the scheduled program and to detect and correct excesses or deficiencies before the end of the month. The illustration shows a typical report made out on one supervisor's district in this region.



UNITED STATES RAILROAD ADMINISTRATION
Director General of Railroads
ALLEGHENY REGION
AB&C. Railroad
DAILY REPORT OF MAN HOURS
May 5 1919
(A)

DEPARTMENT OR OFFICE	CODE	HOURS WORKED Straight Time B	Overtime C	Total D	Allotted E
H. A. Johns.					
Sec. 14	F	80	10	90	90
13	G	72	23	95	90
12	H	72	18	90	90
11	J	64	8	72	81
10	K	64	8	72	81
9	L	56	7	63	81
8	M	72	9	81	81
7	N	80	10	90	81
6	P	56	7	63	81
5	R	56	7	63	81
4	S	88	11	99	135
3	T	48	6	54	54
2	V	48	6	54	54
1	W	40	5	45	45
36	X	88	11	99	117
37	Y	48	6	54	81
38	Z	64	8	72	81
39		72	9	81	81
TOTAL	Za				

CUMULATIVE FIGURES ON REVERSE SIDE

UNITED STATES RAILROAD ADMINISTRATION
Director General of Railroads
ALLEGHENY REGION
AB&C Railroad
CUMULATIVE REPORT OF MAN HOURS
May 5 1919
(A)

DEPARTMENT OR OFFICE	CODE	CUMULATIVE HOURS WORKED Straight Time B	Overtime C	Total D	Allotted E
H. A. Johns					
Sec. #14	F	309	38	347	365
" 13	G	275	51	326	365
12	H	277	41	318	365
11	J	245	30	275	329
10	K	285	35	320	329
9	L	253	31	284	329
8	M	293	[illegible]	329	329
7	N	309	38	347	329
6	P	229	28	257	329
5	R	277	34	311	329
4	S	379	61	440	545
3	T	197	24	221	221
2	V	197	24	221	221
1	W	160	20	180	180
36	X	350	35	385	473
37	Y	197	24	221	329
38	Z	269	29	298	329
39		293	84	377	329
TOTAL	Z1				

DAILY FIGURES ON REVERSE SIDE

Front and Back of Labor Time Record Card.

Time Statement Prevents Pay Day Kicks

On many construction jobs protests by employes that their time has not been properly kept or their pay is short are a fruitful source of vexation. If the records are in order, settlements should be capable of rapid verification or correction. A good method of avoiding disputes is to give the employes a detailed statement of the amount of his earnings with any deductions therefrom, and allow him to consider it before receiving his money. A time statement that meets this requirement is illustrated in a recent bulletin of the U. S. Bureau of Mines in "Cost Keeping for Small Metal Mines." One of these statements is handed the employe; if it is correct he signs and passes it to the paymaster and receives his pay envelope, on the face of which is a carbon copy of the statement. The result is that the company retains a receipt for the payment, and the employe a copy of the statement that he has signed. The time statement is made up in pads, a convenient size being 3½ by 7 ins. A convenient size for the paper pay envelope is 3½ by 7 ins. The statement on the face of the envelope is filled in as carbon copy of the "time statement."

TIME STATEMENT.
.... No.....
In account with
AMERICAN MINING CO.
.... for....
Earnings.
By...shifts at $................
By...shifts at $................
By...shifts at $................
By...shifts at $................
By ....
By ....
By ....
Total earnings ....
Charges.
For doctor ....
For board ....
For room rent ....
For store ....
For ....
For ....
For ....
For cash advanced ....
Total charges ....
Balance as per pay roll ....
Received payment in full for the above services. ....
....
(Sign here)
Not negotiable.

PAY ENVELOPE.
.... No
In account with
AMERICAN MINING CO.
.... for...
Earnings.
By...shifts at $.....
By...shifts at $.....
By...shifts at $.....
By...shifts at $.....
By ....
By ....
By ....
Total earnings
Charges
For doctor ....
For board ....
For room rent ....
For store ....
For ....
For ....
For ....
For cash advanced ..
Total charges ..
Balance as per pay roll ....

Form for Statement of Earnings and Amount of Pay Due.

Personals

George J. Kuss, formerly deputy chief of the fire department of New York City, and later associated with the Bureau of Fire Prevention of that city, has opened consulting engineering offices at 64 W. Broadway, New York, and will specialize in fire prevention and fire protection.

Capts. John Maher, George B. Farlow, Joseph M. Lewis, Paul W. Elmore and Lieuts. W. B. Maurer, J. W. Purdy and J. D. Stemm have been discharged from military service and reported for duty as assistant engineers, Baltimore & Ohio R. R., Western Lines, at Cincinnati, O.

A. B. Hargis, engineer in charge since October, 1917, of the Camp McClellan, Ala., organization of Morris Knowles, Inc., Supervising Engineers, completed his work at this camp in the early summer and was recently transferred to the Pittsburgh office, continuing his connection with these engineers.

M. A. Long has resigned as assistant to the chief engineer and architect of the Baltimore & Ohio R. R. and will engage in general engineering and construction work at 1523 Munsey building, Baltimore, Md., under the name of The M. A. Long Co. The first piece of construction work on which Mr. Long will be engaged will be the design and construction of the McCormick building, Light and Barre streets, Baltimore. This is to be an 8-story reinforced concrete structure, having a floor space of 55,000 square feet and will cost $1,500,000. Mr. Long has been connected with the Baltimore & Ohio R. R for the past 20 years, during which time he has handled a number of important pieces of building construction, among others being the design and construction of the large terminal warehouse of the railroad at Cincinnati, O.; Baltimore, Md.; Pittsburgh, Pa., and New York; piers at Locust Point, station buildings at Grafton, W. Va.; Wheeling, W. Va., and Pittsburgh, Pa.; coal handling plants at Deshler, O.; Elsmere Junction, Del.; Yoder, Pa., and other points; thawing sheds at Baltimore, Md., and New York, N. Y.; icing and cold storage plants and rest houses, Y. M. C. A. buildings, shops and engine houses at Grafton, W. Va.; Parkersburg, W. Va.; Cincinnati, O., and Chicago, Ill. He also superintended the construction of the Baltimore & Ohio general office building at Baltimore and Charles streets, Baltimore Md

Industrial Notes

Leroy A. Kling has organized the Leroy A. Kling Advertising Co., with offices in the Consumers' Building, Chicago, Ill.

The Bucyrus Co., South Milwaukee, Wis., has opened a Cleveland, O., office at 808 American Trust building. This office will be in charge of E. G. Lewis, formerly with the New York office of the Bucyrus Co., and more recently president of the New Jersey Slag Products Co., Dover, N. J.

The Williamsport Wire Rope Co., Williamsport, Pa., has established a branch office and warehouse at Chicago under the direction of C. M. Ballard, formerly connected with the Williamsport organization at Cleveland, O. The Chicago office is located at 122 S. Michigan avenue and the warehouse at 755 W. Quincy street. The new Chicago branch is the latest step in the development of the Williamsport's distribution organization.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently.

Cableways.—Blaw-Knox Co., Pittsburgh, Pa. 16-page bulletin devoted to "Blaw" automatic single rope cableways.

Drill.—Sullivan Machinery Co., Chicago, Ill. 32-page booklet on Sullivan hammer drills and Sullivan rock drills.

Rock Crushers.—Allis-Chalmers Manufacturing Co., Milwaukee, Wis. 20-page bulletin illustrating and describing the Fairmount type crusher.

Locomotive Cranes.—Ball Engine Co., Erie, Pa. Bulletin showing uses to which Erie Type B locomotive cranes can be put; also gives output of machine, working ranges, lifting capacity, etc.

Steam Shovels, Cranes, Dredges, Etc.—The Osgood Co., Marion, O. 32-page catalog of steam shovels, cranes, clamshell outfits and dredges. Contains general descriptions and tables of dimensions of the machines. Numerous construction views are also given.

Building and Structural Monthly Issue

ENGINEERING AND CONTRACTING

Published by Engineering & Contracting Publishing Co., 608 South Dearborn St., Chicago.
HALBERT P. GILLETTE, *President and Editor* LEWIS S. LOUER, *Vice-President and General Manager*
New York Office: 701 Woolworth Bldg., RICHARD E. BROWN, *Eastern Manager*
Cleveland Office: Room 413 Engineers' Bldg., LEO EHLBERT, *Manager*

The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field if subscribed for as a weekly at $3.00 a year; but any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year (or any two monthly issues at $1.50 a year) and the 4 special quarterly issues will be sent without extra charge. Three of these special quarterly issues relate entirely to foreign engineering and construction practice, and the fourth is our annual "New Equipment Issue." The *articles* in the first two issues of each month (1st and 2nd Wednesdays) completely cover the municipal engineering and contracting field. The *articles* in the first and last issues of each month (1st and 4th Wednesdays) completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and last issues of each month (3rd and 4th Wednesdays) completely cover steam and electric railway location, design and construction. See the "mast head" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials

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Volume LII. CHICAGO, ILL., SEPTEMBER 24, 1919. Number 13

The Fallacy of Urging Greater Production of Every Class of "Goods" and Service

The public is being deluged with economic advice from every source, from the President down to the ward politician: from the editor of the greatest daily to the humorist of the smallest weekly. For a time we were told that high prices were due to the abnormal demand for goods created by war conditions, and we were advised to reduce consumption of all things save the barest necessities. Now we are still told to economize, in the face of the fact that production has greatly decreased in nearly all lines save farming. But in the same breath greater productivity of everything is urged as the panacea for high prices! "Produce more and consume less" may be a good economic policy for an individual, provided all other individuals do not follow the same policy, but it spells economic disaster where all individuals follow it.

Few economists think clearly enough to distinguish at all times between individual economy and social economy. A policy that may enrich an individual may impoverish a nation. Take, as an extreme illustration, the brigandage policy of Pancho Villa. To him and his associates it brings wealth, but to the rest of Mexico it brings poverty. Not less disastrous would it be to a nation were all men as miserly as Russell Sage was reputed to be.

Fully 90 per cent of all that is produced is consumed almost at once, the remaining 10 per cent going to increase the working capital—railways, highways, plants, buildings, tools, etc. In other words, a normally prosperous nation immediately consumes nine-tenths of all it produces. Hence it is contradictory to counsel national restriction of consumption and national increase of production at the same time. Yet that is precisely what the U. S. Council of National Defense has recommended in the report that we abstracted in our issue of Sept. 3.

The same report contains several other glaring inconsistencies. For example, it attributes the continuance of high prices to reduced production since the war ended. Yet it gives statistics showing that farm production for 1919 has been greater than for the abnormally great year of 1918, while food exports have decreased. In other words, America has more food per capita now than it had a year ago, yet the retail food prices remain substantially the same. Clearly, then, high prices of foods can not be attributed to decrease in food production.

Undaunted by this fact, the report ascribes the high price of shoes and textiles to the 27 per cent decrease in their production that has occurred during the first half of 1919 compared with the first half of 1918. But if decreased

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

production of clothing has kept prices up, and if increased production of foods has also kept prices up, is there not something wrong with the theory that high prices are mainly dependent on decreased production? Is it not more probable that food is produced in as large quantities as ever because people insist on eating heartily, whereas clothing is being produced in smaller quantities because many people are making their old clothes last longer? If so, it will be idle advice to increase all production; first, because increased production of food is not necessary, and would result in waste; second, because increased production of clothes will not give enough underpaid people the income needed to buy both food and clothes in ample quantities.

The economists who wrote the report for the U. S. Council of Defense certainly have confused the need of greater annual productivity per man with greater annual productivity of all goods. It is a very common error to reason that because greater annual productivity per worker is a desideratum, therefore greater annual production of every sort of goods is to be desired. To illustrate the absurdity of such an inference, take the case of drinking water. Each person needs about 50 gallons of water per day for domestic purposes. More than that is simply waste. Yet, under the theory that general productivity of all things is desirable, it would be relatively easy to supply 100 gal. per diem per capita for domestic purposes, with practically no increase in the number of employes of a water works plant. Relatively slight increase in the size of the plant—the pumps, engines, etc.—would double the water delivered daily to each consumer. But to what useful end?

About 4 lb. of solid food per day per person suffices, and we in America are getting all of that and more. Why, then, urge farmers to greater productivity? The farmers are too keen to glut the market so as to lower prices without increasing their own net income. Even the Japanese gardeners of California know that much of economics, for they have been destroying their surplus garden truck. The fruit associations and other farm organizations are altogether too well informed to produce much more than can be readily absorbed by the markets. So the President may as well shout into an empty rain barrel as to urge American agriculturists to increase their production.

Does it follow from the foregoing facts that "greater productivity" is a futile preachment? Not at all, if the term "greater productivity" is properly understood and correctly defined, which it rarely is. While there are some things that we now produce in great abundance, notably food, there are other things that we lack, notably adequate education, adequate housing, adequate transportation, and adequate amusements. The primary object of greater productivity per man per hour is to release men for employment in occupations that will yield an abundance of the things that we now lack—houses, roads, railways, amusement grounds and places, education. Increasing the annual productivity of each worker is obviously in the interest of all workers, but only when it is so managed that the output of each class of goods does not exceed the demand for that particular class. If farmers and manufacturers follow the advice of President Wilson and others who are now urging a general increase in production, nothing but disaster will come to most of those that act upon the advice.

When the war came to its sudden end, nearly a year ago, we urged the economic necessity of huge expenditures for public works. Altogether inadequate amounts have been appropriated for such purposes. Railway and public utility companies have added next to nothing to their plants in five years. The same holds true of municipalities. Aside from roads construction there has been comparatively little spent for works of a public or semi-public nature. Railways and public utilities generally had been starved by public repression for many years before the war. The inflation of the currency during the war put the finishing touch to their troubles. Cities limited as they are by antiquated charters and laws, can not bond themselves for large enough sums for adequate improvements. The federal government has made no move to improve rivers and harbors, or to irrigate and drain lands on a large scale. Its miserly federal appropriations for road work have been insufficient to give employment to many men.

When great railway and public utility companies are financially unable to improve their plants, when cities are doing little construction and the federal government is doing less, how can politicians hope to persuade private corporations and individuals to build plants and houses, and "get busy" generally? Let the government set a proper example. Let cities, counties and states add greatly to their "plant"—their paved highways, their school buildings, their amusement grounds for old and young, their sewer and water systems.

Let prompt action be taken one way or the other as to the currency. If it is decided not to attempt to deflate the currency, then let the decision be voiced in a law, and coincidently, let the salaries and wages of all public servants be increased fully 60 per cent above the prewar level. Also let propaganda be started to secure a similar increase for every class of private employe. In short, let the entire nation come to the new standard of value as quickly as possible. The strike of policemen in Boston is merely symptomatic of the general unrest among millions of men who have received no wage increase corresponding to the 50 per cent increase in currency and bank deposits, to say nothing of the 70 per cent increase in the cost of living.

Following a prompt decision as to the currency, propaganda should be started to increase the productivity per man-hour in every occupation, with the definite object of releasing men for occupations that will yield products for which the demand exceeds the supply. Coincidently, advertising and other educational methods should be used on a large scale to create demands for sensible things. First among these sensible things we would place better education. Far as we have gone in America to provide free education for the masses, we are as yet only on the threshold of educational achievement. Contrast the average workman with, say, the average civil engineer, if you would appreciate the gulf that exists between what we have yet done in an educational way and what we may still do.

The ultimate goal is greater leisure for all, better education and training that will not only bring this leisure but habits that will make it most enjoyable. Against the coal miners who are asking for a 6-hour day and a 5-day week, let us not shoot our arrows of derision. Let us agree with them that their desire is a worthy one—when it can be obtained by all American workmen. And let us show them that while it is not to be attained at once, it is already within the sight of anyone that is not blinded by habit or prejudice. First, however, all workmen must be taught to speed up; and all employers must be taught to share up. This need not be an interminable task. Ten years of well directed, vigorous effort might bring it to pass.

Why Engineers are More Judicial Than Lawyers

By training, and perhaps by instinct also, most lawyers are strongly partisan. By training, and perhaps by instinct also, most engineers are judicial. Yet lawyers occupy nearly all judicial positions in public life, because of their ability as public speakers and "mixers," aided by the popular belief that it is the peculiar function of lawyers to interpret laws as well as to make them. Like many another common fallacy, this one has sprung from failure to define terms carefully.

A law is a rule for the guidance of conduct, supported by an authority having the power to punish its infringement. A lawyer is one whose profession it is to defend or prosceute alleged infringers of the law, and to guide clients so as to avoid litigation. It does not follow, therefore, that a lawyer is necessarily a maker of laws, although it does follow that he should be a reliable interpreter of their meaning. The training in precise use of language is one of the advantages that the average lawyer has over the average engineer, both in drafting and in interpreting a law. On the other hand, the economic and scientific training of the average engineer gives him a marked advantage over the average lawyer in deciding what a law of an economic nature should prescribe. If the engineer is also well trained in the use of words, his knowledge of the full significance of technical terms gives him an advantage in drafting a law wherein such terms are used.

In rendering judicial decisions in cases of a technical or economic nature—such as appraisal and rate cases, tax cases, patent cases, etc.—an engineer is, as a rule, better equipped than a lawyer to reach a fair decision; for in such cases an interpretation of the meaning of a law, or a decision as to what law applies, is usually not involved, whereas the fairness of the decision almost invariably rests upon a correct interpretation and weighing of the data submitted in the evidence. The weighing of technical and economic data is a matter of daily, almost hourly, occupation on the part of all engineers, excepting those whose duties are of a purely routine nature.

In each field of human activity, the most competent weighers of evidence that pertain to that field are the men whose occupation has involved systematic study and practice in that particular field. Doctors are the best judges of symptoms of disease, even as civil engineers are the best judges of economic facts of an engineering nature. Every careful student of logic knows this to be true, and any thinking man can readily satisfy himself that it is, if he will merely review the instances of errors made by those who enter a new field of activity—the "greenhorns."

Due to the wide range of the laws that they are called upon to interpret for clients, lawyers are prone to believe that theirs is the one profession that trains a man to think correctly on every mundane subject. Consider the cocksureness of the average politician, bearing in mind that the average politician is a lawyer. From the President down we see the greatest self-confidence in answering any and every economic question, almost offhand. In contrast, note the reserve of a great scientist or engineer when a new economic problem is presented for his consideration, even though the problem is one that falls within his specialty. And if it lies outside his realm of every day thought, note his extreme reticence about even undertaking its solution.

It has been pointed out by psychologists that children and ignorant men are prone to jump to conclusions. They are called emotional, because of the ease and rapidity with which they form judgments. On the other hand, mature men, and particularly those that are recognized as great men, are much more deliberate in forming judgments. They are called unemotional, or judicial. A scientific training develops the judicial faculty or habit in the highest degree; whereas a legal training falls far short of such an accomplishment. An engineer, for example, wants an abundance of data before he decides. A lawyer usually is ready to decide as soon as he has read the law and listened to his client's statements. Lacking adequate data, an engineer wants to experiment to secure the facts needed to form a correct judgment. Lacking adequate evidence, the average lawyer is prone to trust to his wit and his persuasive tongue. The one seeks a "correct solution" of each problem, while the other seeks a "victory" in every contest.

In the present public discussion of the proposed law to administer the railways under the "Plumb plan," lawyers on both sides are illustrating their proclivity for solving an economic problem by mere argument. Plumb, himself a lawyer, makes no effort to investigate available data, but indulges in such misstatements as this:

"I have been uttering before the Interstate Commerce Committee of the House of Representatives this charge: The railroad executives, whose securities are over one-third below par on the market, are conspiring to get a law through Congress guaranteeing 6 per cent dividends on all these securities, good and bogus—and half of them, according to the valuations of the Interstate Commerce Commission, are worthless—as though their value was at par. No one has had the hardihood to deny that charge."

Where are Interstate Commerce Commission valuations that show that "half the railway securities are worthless"? The I. C. C. has not yet rendered a single decision as to the value of any railway, and has published the engineers' estimates of physical property values on but a few small railways. So much for Mr. Plumb's data.

On the other side of the controversy lawyers, like Senator Pomerene, cite the government deficits in railway operations as evidence that "democratization of the railways" is an economic failure, in spite of the fact that this "democratization" is not what the "Plumb plan" calls for. In short, data that have no real bearing on the problem are cited as conclusive evidence

Lack of economic training combined with lack of a scientific training that develops the judicial habit account largely for the fact that lawyers are not as competent judges as are engineers. This is true in general, but it applies with special force where the judging relates to economic matters.

Why Mr. Newell Should Personally Urge the President to Appoint an Engineer on the I. C. C.

Frederick H. Newell, president of the American Association of Engineers, has written President Wilson urging him to appoint an engineer to fill the vacancy in Interstate Commerce Commission. The association would do well to have Mr. Newell see the President in person, for a vocal presentation of reasons is invariably more persuasive than a written argument.

About a year ago the editor suggested to the governor of Nevada that an engineer should be appointed to fill a vacancy on the State Public Utilities Commission The governor, himself an engineer, replied that the commission employed a competent engineer, and that there seemed to be no real need of having an engineer on the commission Nevertheless, he ultimately did appoint an engineer. In doing so he was probably influenced by the argument that a technical case is usually best decided by a technical court. This, we believe, is the strongest single reason why a public service commissioner should be a technically trained man

Not long ago the Engineers' Club of Sacramento asked the governor of California to appoint an engineer on the railroad commission. The governor, although he had once been an engineer, refused to make such an appointment because he feared that an engineer's mind would be made up in advance of any hearing as to the value of public utility properties. Probably the governor thought that an engineer commissioner would be inclined to supervise the appraisal work of the engineers of the commission, and thus come to have an opinion favorable to their findings prior to hearing the testimony of the engineers of the public utility companies. It is not to be denied that there is foundation for such a fear, provided the engineer commissioner is of the type that tends to usurp the functions of other people. But is it not a sufficient answer to such an objection to state that the governor need not appoint an engineer of that type? There are numerous engineers of judicial temperament, even as there are numerous lawyers that lack such a temperament. A man's temperament is not necessarily indicated by the profession to which he belongs.

The ideal service commissioner should be courageous, judicial, fair, and sufficiently versed in the technical and practical details of public utility financing, construction and operation to avoid serious errors in rendering a decision. In this last named qualification, engineers, as a class, lead every other class. Among the 40,000 engineers that are members of national engineering societies there are thousands that possess the three remaining essential qualities of the ideal public service commissioner.

Mr. Newell himself is a splendid example of the judicially minded, fair and courageous engineer Hence his particular fitness for the task of convincing the President by personal appeal, as above suggested.

Difference Between Heartwood and Sapwood

In over 300,000 tests which have been made at the Forest Products Laboratory, Madison, Wis., on the various species of wood grown in the United States, no effect upon the mechanical properties of wood due to its change from sapwood into heartwood has ever been noticed. Any difference in the strength of heartwood and sapwood can usually be explained by the growth and density of the wood.

In other than mechanical properties, there are differences between heartwood and sapwood which have an important bearing on their use for various purposes. The sapwood of most American species is considerably less resistant to decay than the heartwood, and where the wood is used without preservative treatment in situations which favor decay, the sapwood is likely to have a much shorter life. In these particular cases, therefore, strength requirements may have an indirect bearing on the choice between heartwood and sapwood, inasmuch as wood infected with decay is likely to have its strength properties, particularly that of shock resistance, greatly reduced.

Erroneous Economic Articles in the Daily Press and How to Reduce Their Number

By HALBERT P. GILLETTE, Editor.

When will American daily papers come to realize that it is an economic crime to publish articles on economic subjects by authors that lack adequate economic knowledge? Probably not until scientific and professional men go to the editors and publishers of daily papers and show them the blunders that non-technical authors are constantly making.

As an illustration of the sort of current literature that is reprehensible because of its technical errors I will cite a recent article in the Los Angeles Times by Frederick J. Haskin. Mr. Haskin's theme is the high cost of retailing products. He gives the following examples to illustrate the point: No. 1, "a certain popular safety razor which sells for $5 is made at a shop cost of one-tenth of that amount." No. 2, it costs 0.5 to 0.75 ct. per kilowatt hour to generate electricity from coal, but "the public, in most places, may have to pay 10 ct. per kilowatt hour." No. 3, "the shop cost of making a high-grade typewriter to sell for $100, is estimated by experts at from $12 to $18 each." No. 4, an electric motor that sells for $6 can be made for $1.

It is apparent that Mr. Haskin does not know the meaning of the technical term "shop cost," for he says:

"Shop cost includes labor, materials, interest on the actual investment in machinery, and the amount involved in the deterioration of the machinery. It does not include the salaries of executives, and other purely administrative expenses. It is the actual cost of making the article."

As a matter of fact "shop cost" includes no "overhead costs"—not even interest, depreciation or taxes on the plant. Usually the "overhead costs" of manufacturers equal or exceed the "shop costs." In the case of the $5 safety razor, the major part of the cost is the cost of advertising and the discount to the retail dealers. I was told several years ago (by a man who knows) that the cost of selling a $5 safety razor was $2. Mr. Haskin states that the sales company that markets this razor pays the manufacturer $2 a razor. If, then, the selling cost and discount is $2 more, the profit to the selling company is not more than $1. If the "shop cost" of the razor is 50 ct., it is probable that the overhead costs are another 50 ct., making a total "manufacturing cost" of $1. The resulting $1 profit made by the manufacturer would be properly regarded as very great, were it not that the razor is patented. Moreover, this was the first safety razor ever manufactured and sold in large quantities. Prior to its use, millions of men either spent 15 ct. for a shave or butchered their faces. At 15 ct. a shave three times weekly, the cost of being shaved is $23.40 a year, to say nothing of the value of the time lost waiting to be shaved. So the man that pays $5 for the safety razor saves its full price in less than 3 months. But in order to induce the average man to make an annual profit of more than 400 per cent on his $5 investment in a safety razor, it was necessary to conduct a great educational campaign. The cheapest way to educate the average man to buy a given thing is by advertising. So, even though it costs $2 per razor to advertise it, the cost of educating men to use a safety razor is very moderate compared with the saving affected by its use. Surely the inventor of the safety razor is entitled to $1 a razor during the 17-year life of his patent. Not less certain is it that the man at the head of the sales company is entitled to another dollar per razor for the novelty of his idea in marketing the razor in great numbers by liberal advertising. Mr. Haskin says of this man:

"It is said that the man who designed and first made this razor, for less than half a dollar, intended to sell it for a dollar. He could have made a nice profit at that figure, and could have done a certain amount of advertising, which is, of course, absolutely necessary. His business associate expressed the opinion that the razor could be sold for much more than a dollar. The inventor disagreed. They ended by forming two corporations—a manufacturing company and a sales company. The sales company bought the output of the manufacturing company at $2 for each razor, and sold the razors for $5 each. Moreover, it sold millions of them all over the world. African chiefs and South Americans and Russians have corroborated the judgment of the sales manager that the public would pay $5 for a 50-cent razor, just as quickly as it would pay $1."

The "business associate" who conceived the idea of putting a $5 price on this invention, and who had the courage to plan and the ability to execute a great selling campaign, is as much entitled to reward as the inventor himself. The public is prone to overlook the gain that it realizes from the exercise of brains by such men as the man who conceived and executed the great idea of educating millions of men to use a safety razor. Mr. Haskin not only overlooks this economic factor entirely, but fails even to see that the inventor of the safety razor was entitled to a liberal reward.

Passing to Mr. Haskin's second example, we have another sort of economic blunder on his part. It is true that electric current could be generated for about three-quarters of a cent per kilowatt hour prior to the war, but only where the "load factor" was very high, the plant large, and the price of coal low. Now it happens that the average householder has a very low "load factor," since he uses current only about 3 hours out of the 24, and even then not ordinarily up to the capacity of his lamps, etc. Nevertheless, there is the annual interest, depreciation and taxes on the meter, wires and poles that serve him, entirely independent of the number of hours that he uses the current. Reading a customer's meter, billing him, bookkeeping, interest, depreciation and repairs on the meter and service wire from the street to the house amount to about $7.50 per residence customer per year (at pre-war prices). But the average residence customer uses only 250 kilowatt hours per year, so that this "service cost" alone amounts to 3 ct. per kilowatt hour. To this must be added the cost of generating current at the low station load factor (say, 15 per cent) attributable to residence customers or about 2.5 ct. per kilowatt hour. And to this must be added the cost of distributing the current also at this low load factor, or about 2 ct. per kilowatt hour. This makes a total prewar cost of 7.5 ct. per kilowatt hour for the average residence customer of a steam-electric plant, allowing 7 per cent interest on the investment. The reader is referred to pages 62 to 82 of the Handbook of Mechanical and Electrical Cost Data, by Gillette and Dana, for a detailed analysis of the costs of generating and distributing current to different classes of customers.

To Mr. Haskin the gap between a generating cost of 0.8 ct. per kilowatt hour (at a 50 per cent station load factor) and an 8 ct. per kilowatt hour charge, a residence customer (at a 15 per cent station load factor) seems to indicate either woeful economic management or profiteering, for he says:

"It may be argued that the other 9 ct. (the difference between a 1 ct. cost of generating and a 10 ct. price) is cost of distribution, but the argument will hardly hold. It costs less to distribute electric current over a wire than it does to distribute other commodities by auto or horsepower. Yet, almost any commodity can be distributed in the latter way for far less than 900 per cent of its value. And, besides, the companies that supply the Government current at 2 cents are not losing money. This discrepancy between shop cost and selling price represents economic waste, and is a large factor in the high cost of living. There is no intention here to fix, or even suggest blame for this waste. It may be due in part to the charging of excessive profits by the manufacturer, the wholesaler, the retailer, or all three. It may be due in part to wasteful and inefficient methods on the part of one or all of these factors. It may be due primarily to the fact that our whole industrial system is loosely and inefficiently organized."

Mr. Haskin's attempt to reason by analogy between the cost of distributing electric current by wire and hauling commodities by auto truck is an excellent illustration of his lack of knowledge of industrial economics. Yet he evidently is one who seeks to reform economic ills! But I blame such economically uneducated writers less than I blame the periodicals that publish their deceptive illustrations and inferences. Perhaps we should carry the blame still farther back, and place it upon the shoulders of engineers and other economists who fail to point out to editors of daily papers and magazines the economic blunders made by their contributors.

Engineering societies have been derelict in their public duty in not attempting to persuade the public press to eliminate economic articles by non-technical men, unless such articles have been edited by men competent to judge their truth.

Preservation of Timber With Zinc Chloride by the Steeping Process

Frequently small amounts of timber are to be used under conditions that favor decay, when it is inexpedient to have the timbers treated at a commercial treating plant, and yet where a simple and inexpensive preservative treatment is desired. Coal-tar creosote is easily applied, but this preservative may be objectionable on account of its color or odor, or the possible fire risk involved. It is in such cases that the zinc-chloride steeping process may be used to advantage.

The steeping process can not be expected to make wood as durable as impregnation under pressure, because the absorption and penetration of the preservative are usually not as thorough. Furthermore, a water-soluble preservative like zinc chloride can not be recommended for timbers which are exposed continuously or frequently to the leaching action of standing or running water.

If the timbers are to be used where there is little leaching action of water, even if they are in direct contact with damp ground, the zinc-chloride treatment may be expected to add more than enough to their length of life to justify the cost of treatment. It should be borne in mind, however, that much better results and usually greater economy can be obtained by the use of timber thoroughly treated under pressure, and commercial treating plants should be employed whenever conditions permit.

About the only special apparatus required in the steeping process is a sheet iron, wood or concrete tank long enough so that the largest sticks to be treated can be submerged in it.

Only absolutely sound timber should be used and it should be thoroughly seasoned before treatment. If the wood is seasoned but wet from snow or rain, it should be dried out again before treating.

The timbers should be cut to final dimensions and all boring and framing done before treatment if possible. In case it is necessary to cut into the timbers after treatment, all faces exposed by the cutting should be painted with two coats of hot coal-tar creosote, or with two coats of a strong solution of zinc chloride.

Zinc chloride can be purchased either in solid form or in a 50 per cent water solution. For treatment by the steeping process it should be dissolved in water to form a 5 per cent solution. This can be done by mixing 5 lb. of the solid zinc chloride and 95 lb. of water, or 10 lb. of the 50 per cent solution and 90 lb. of water. The solid form absorbs the water from the air rapidly and will soon dissolve itself in this way. It should, therefore, be mixed in solution as soon as the package is opened.

As the timbers are being piled into the vat, stickers should be placed between the courses, so that the preservative solution will be able to reach every part of each stick.

It is customary to allow the wood to soak 1 day for each inch of thickness and 1 additional day. Thus, a 1-in. plank should soak 2 days, one 6-in. thick 7 days, a 12-in. timber 13 days, and so on. Longer steeping, however, would probably result in better absorption and penetration of preservative, and when time is not an important factor, it would be advisable to use a longer soaking period.

If the timbers are to be used in contact with the ground, in damp places, or in places where slight shrinkage would be objectionable, they should be seasoned for a week or two after treatment before being used.

Improving the Patent Office

Mining and metallurgical engineers will be interested in noting the progress being made by Engineering Council in its efforts to strengthen the Patent Office. With the co-operation of the National Research Council and the staff of the Patent Office, remedial legislation has taken form, and three bills have been introduced bearing on this question. H. R. 5011 detaches the Patent Office from the Department of the Interior and simplifies the procedure of the courts with reference to assessment of damages or profits for infringement. H. R. 5012 establishes a single Court of Patent Appeals, and H. R. 7010 increases the force and salaries in the Patent Office.

If legislators realized the importance of the proposed changes as do many engineers the proposed measures would be enacted speedily. Unfortunately, many legislators have not come into close contact with patent litigation, and fail to realize the crude condition of our laws. Unless advised of this by their constituents, and impressed by them with the necessity of revision, enactment will probably fail or be indefinitely postponed.—Editorial in Engineering and Mining Journal.

Coatings That Prevent End Checking of Timber

Wood, whether in the form of logs, lumber, timber, shaped blanks or veneer, will split and check at the ends during seasoning if drying is allowed to go on at a natural rate through the end grain. To retard the rate of drying from the ends, it is necessary to cover them with some protective coating.

The law of end coatings, in simple terms, is that the harder and greener the wood, the more effective must be the coating. In its experiments to determine the practicability of various coatings and end dips, the Forest Products Laboratory found the following to be true:

Paint is convenient to handle, but is of low effectiveness.

White lead is convenient to handle, and is of medium effectiveness.

Lorac, a commercial compound, is convenient to handle, and is of considerable effectiveness.

Rosin-lampblack is inconvenient to handle, but is of high effectiveness.

Rosin-lampblack is made according to the following formula:

Clear grade rosin, 60 parts by weight.

Lampblack, 1 part by weight.

The rosin should be melted but not allowed to boil or froth. The lampblack should then be thoroughly stirred in. The ends of the sticks should be dipped in this molten mixture to a distance of about ½ in. When hard, the coating should be smooth, free from bubbles, shiny, and an eighth of an inch thick over the end.

If the stock is to be subjected to rough handling which might cause the coating to chip when cool, linseed oil may be added, in the proportion of 1 to 15 by weight, but this will have a tendency to make the coating excessively soft in the kiln at temperatures above 130° F.

Standard Wage of $1 Per Hour in Chicago Building Trades.—Following the settlement of the carpenters' strike in Chicago, a new scale of $1 per hour has been agreed upon for the following classes of labor in the Chicago building trades:

Trades.	Wage Sept. 20, 1918.	Trades.	Wage Sept. 20, 1918.
Asbestos workers	$0.76¼	Machinery, safe movers and riggers	.80
Boilermakers	.80	Marble workers	.75
Bricklayers	.87½	Marble workers, mosaic	.75
Carpenters	.80	Machinists	.87
Cement finishers	.80	Plasterers	.87½
Drain layers	.68¾	Painters	.75
Electricians	.87½	Plumbers	.81¼
Elevator constructors	.87	Roofers, slate	.80
Fixture hangers	.81¼	Roofers, composition	.75
Gasfitters	.81¼	Roofers, tile	.80
Glaziers	.75	Sprinkler fitters	.80
Hoisting engineers	.87½	Sheet metal workers	.75
Ironworkers, ornamental	.80	Steamfitters	.81¼
Ironworkers, structural	.87½	Stonecutters	.81¼
Ironworkers, architectural	.87½	Tile setters	.81¼
Lathers	.80	Tuck pointers	[illegible]

Architects Can Join American Association of Engineers.—The executive committee of the American Association of Engineers has rendered a decision that the constitution of the association does not prohibit the admission of architects, and announces that the applications of architects will be considered hereafter as in the same status as applications from engineers. Those architects who have previously applied for membership and whose applications could not be accepted on account of the apparent exclusion of architects by the constitution, may now re-enter their application for membership.

Seventy-eight Per Cent Capacity of Structural Shops Contracted for in August. The records of the Bridge Builders and Structural Society as collected by its secretary, show that during the month of August 1919, 78½ per cent of the entire capacity of the bridge and structural shops of the country was contracted for.

Some Notes on Indeterminate Structures

By GEORGE PAASWELL,
Consulting Engineer, 212 West Fordham Road, New York City.

The analysis of the two following structures has been occasioned by the investigation of the strength of existing work, with a view to ascertaining the actual stresses in the members. Literature is very meager on the subject and it may be worth while to record the actual results obtained.

Continuous Girder with Fixed Ends.—A beam resting upon four supports as shown in Fig. 1, has fixed ends and carries a uniform load of w per foot. The condition of fixed ends implies this one terminal condition, namely, that the tangent to the elastic curve at the support is horizontal. The fixed ends may then be replaced by structures as shown in Fig. 2. the beam being simply extended to form a symmetrical beam about the fixed support. The theorem of three moments is now applied as follows: Over the first three supports

$$M_b + 4M_a + M_b = -\,wa^{2}2.$$

or, $$2M_a + M_b = -wa^{2}4. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Again, over the next three supports,

$$a\,M_a + (2a + 3b)M_b = -\frac{w}{4}(a^3 + b^3) \quad \ldots\ldots\ldots\ldots (2)$$

From (1) and (2), the values of the two moments are found to be upon placing $a = kL$; $b = jL$:

$$M_a = -\frac{wL^2}{12}\,\frac{k^3 + 3k^2j - j^3}{k + 2j}$$

$$M_b = -\frac{wL^2}{12}\,\frac{k^3 + 2j^3}{k + 2j}$$

With the moments known, the true reactions are easily found.

The above method is, of course, applicable to any type of loading.

Stresses in a Framed Bent with Center Supports.—The analysis of the structure shown in Fig. 3 is quite complex, unless note is taken of the configuration of the elastic curve. For symmetrical loading, the only character of loading considered here, the tangent at C is horizontal. Reversing the assumption made in the previous note, the condition of continuity at C is replaced by a fixed support at C. It is then necessary to treat the simple shape shown in Fig. 4. To apply this frame to the one under discussion, it must be understood that whenever a load is placed upon the frame in Fig. 4, a symmetrically placed load is assumed on the portion of the completed figure omitted.

Assume a load as placed in Fig. 5. The method of the theory of least work is used here. The moments between the points A, B, C, are as follows:

From O to h: $M_x = Hx + M$.
O to a: $= Hh + M + Vx$.
a to b: $= Hh + M + Vx - P(x - a)$.

By taking moments, the value of V is

$$V = -H\frac{h}{b} + P\frac{b - a}{b}$$

The work of the moment is expressed by the relation

$$\text{Work} = \frac{1}{2EI}\int_0^a M^2dx.$$

The fundamental principle of the theory is that the derivative of the expression for the work, with respect to a force that does no work (e. g. a force applied at a fixed point) is zero. By a principle of the integral calculus, it is permissible to differentiate under the integral sign with respect to a quantity not the variable of the integrand. This latter principle simplifies, to a large degree the algebraic analysis in reducing the expressions.

Determining the expression for the work, using the moment equations as found above and then differentiating this expression before integrating, with respect to M and H, two equations result:

$$\frac{d(\text{Work})}{dH} = \frac{1}{I_2}\int_0^h (M + Hx)x\,dx + \frac{h}{I_1}\int_0^b \left[M + Hh\left(1 - \frac{x}{b}\right)\right]\left(1 - \frac{x}{b}\right)dx + \frac{h}{I_1}\int_0^a \frac{b-a}{b}Px\left(1 - \frac{x}{b}\right)dx + \frac{h}{I_1}P\frac{a}{b^2}\int_a^b (b-x)^2\,dx = 0\cdot$$

$$\frac{d(\text{Work})}{dM} = \frac{1}{I_2}\int_0^h (M + Hx)dx + \frac{1}{I_1}\int_0^b \left[M + Hh\left(1 - \frac{x}{b}\right)\right]dx + \frac{1}{I_1}\int_0^a \frac{b-a}{b}Px\,dx + \frac{1}{I_1}\int_a^b \frac{a(b-x)}{b}\,dx = 0.$$

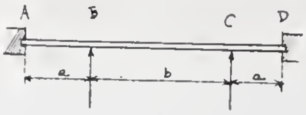


FIGURE 1

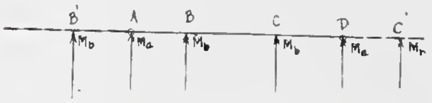


FIGURE 2

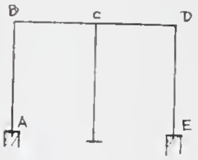


FIGURE 3

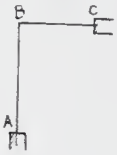


FIGURE 4

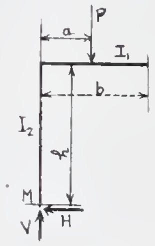


FIGURE 5

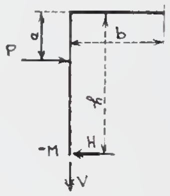


FIGURE 6

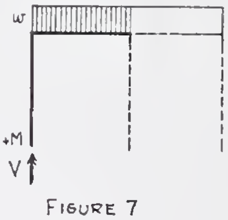


FIGURE 7

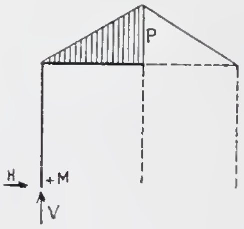


FIGURE 8

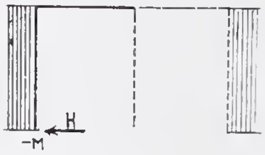


FIGURE 9

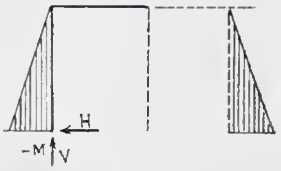


FIGURE 10

When the expressions are integrated and solved the values of M, H, V are (V is found from the relation given before):

$$M = P\frac{a^2(b - a)}{b}\,\frac{I_2}{hI_1 + bI_2}$$

$$H = P\frac{a(b - a)(b - 2a)}{bh}\,\frac{I_2}{hI_1 + bI_2}$$

$$V = P\frac{b - a}{b}\left[1 - \frac{a(b - 2a)}{b}\,\frac{I_2}{hI_1 + bI_2}\right]$$

To apply the above to a uniformly distributed load of intensity w, replace P by w da and integrate between the limits of O and b. To apply to a triangular distribution of loading, with maximum intensity p at C, replace P by $\frac{a}{b}p$ and integrate between the same limits.

For a side loading as shown in Fig. 6, note that by interchanging the wall dimensions and functions, the above equations can be used here. It is necessary to express the moment, H and V, in terms of the corresponding functions at the other terminal to get the moment, horizontal and vertical forces at B for this case. A table of these functions for the several types of loading follows:

Replace the expression $\frac{hI_2}{hI_1 + bI_2}$ by A, and $\frac{hI_1}{hI_1 + bI_2}$ by B.

Form of Loading.	Figure	M	H	V
Concentrated load P on roof	5	$PA\frac{a^2(b-a)}{b^2}$	$PA\frac{a(b-a)(b-2a)}{hb^2}$	$P\frac{b-a}{b}\Big[1-$ [illegible] $\Big]$
Concentrated load P on side wall. ..	6	$-PB\frac{a^2(h-a)}{h^2}$	$P\frac{a}{h}\left[1-B\frac{(b-a)(h-2a)}{h}\right]$	$PB\frac{a(h-a)(h-2a)}{bh}$
Uniform load w on roof	7	$Aw\,b^2/12$	0	$wb/2$
Triangular loading upon roof....	8	$A\,pb^2/20$	$\frac{A}{60}\frac{pb^2}{h}$	$\frac{pb}{6}(A/10+1)$
Uniform load v on sidewall ..	9	$-B\,vh^2/12$	$vh/2$	0
Triangular loading upon sidewall....	10	$-B\,qh^2/20$	$\frac{qb}{3}(1-B/20)$	$\frac{Bqh}{60b}$

Calculating the Volume of Piles and Poles

To determine the amount of preservative per cubic foot of wood absorbed by piles and poles during treatment, an accurate estimate of the volume of the pieces is necessary. The most practical way of finding the volume of such timbers is to measure the diameter at a number of points and calculate the volume from a formula or volume table.

The volume table which follows is the so-called "Santa Fe" table, revised and expanded by the Forest Products Laboratory. It is absolutely correct only for poles of uniform taper, but errors from sources such as irregular shape and large checks may be diminished if circumference measurements are taken at short intervals and the volume of each short section is computed separately. In using the table, an attempt should be made to secure the average diameter of ends which are not true circles.

The values in this table were calculated by the cone-frustum formula:

$$V = 0.2618\,L\,\frac{(D^2 + d^2 + dD)}{144}$$

where V is the volume, L the length, D the top diameter, and d the butt diameter. The middle diameter is obtained by averaging the two end diameters.

Two other formulas are offered below, either of which will give results sufficiently accurate for ordinary purposes. One is the prismoidal formula.

$$V = \frac{L(A_1 + 4A_m + A_2)}{6}$$

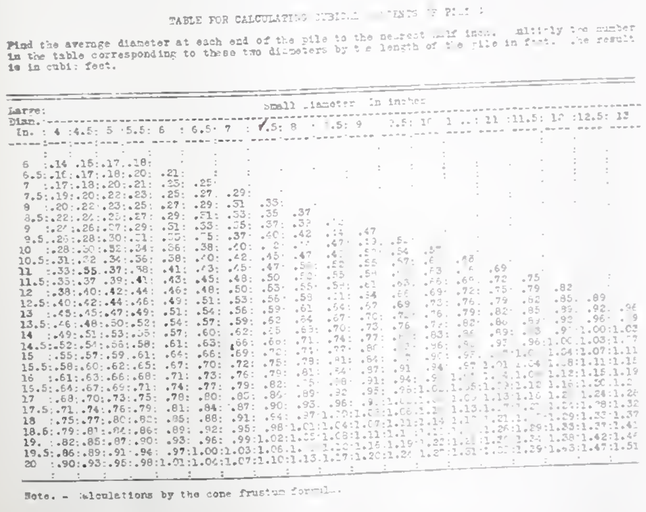


TABLE FOR CALCULATING CUBICAL CONTENTS OF PILES

Find the average diameter at each end of the pile to the nearest half inch. Multiply the number in the table corresponding to these two diameters by the length of the pile in feet. The result is in cubic feet.

Large Diam. In.	Small diameter in inches: 4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13
6	.14	.15	.17	.18															
6.5	.16	.17	.18	.20	.21														
7	.17	.18	.20	.21	.23	.25													
7.5	.19	.20	.22	.23	.25	.27	.29												
8	.20	.22	.23	.25	.27	.29	.31	.33											
8.5	.22	.24	.25	.27	.29	.31	.33	.35	.37										
9	.24	.26	.27	.29	.31	.33	.35	.37	.39	[illegible]									
9.5	.26	.28	.30	.31	.33	.35	.37	.40	.42	.44	.47								
10	.28	.30	.32	.34	.36	.38	.40	.42	[illegible]	.47	[illegible]	[illegible]							
10.5	.31	.32	.34	.36	.38	.40	.42	.45	.47	[illegible]	[illegible]	.54	[illegible]						
11	.33	.35	.37	.38	.41	.43	.45	.47	[illegible]	.52	.55	.57	[illegible]	.63					
11.5	.35	.37	.39	.41	.43	.45	.48	.50	.52	.55	.58	[illegible]	.63	[illegible]	.69				
12	.38	.40	.42	.44	.46	.48	.50	.53	.55	.58	.61	.63	.66	.69	.72	.75			
12.5	.40	.42	.44	.46	.49	.51	.53	.56	.58	.61	.64	.66	.69	.72	.75	.79	.82		
13	.43	.45	.47	.49	.51	.54	.56	.59	.61	.64	.67	.69	.73	.76	.79	.82	.85	.89	
13.5	.46	.48	.50	.52	.54	.57	.59	.62	.64	.67	.70	[illegible]	.76	.79	.82	.85	.89	.92	.96
14	.49	.51	.53	.55	.57	.60	.62	.65	.68	.70	.73	.76	[illegible]	.82	.86	[illegible]	.93	.96	[illegible]
14.5	.52	.54	.56	.58	.61	.63	.66	.68	.71	.74	.77	[illegible]	.83	[illegible]	.89	.93	[illegible]	1.00	1.03
15	.55	.57	.59	.61	.64	.66	.69	.72	[illegible]	.77	.80	[illegible]	.86	[illegible]	.93	.96	1.00	1.03	1.07
15.5	.58	.60	.62	.65	.67	.70	.72	.75	.78	.81	.84	[illegible]	.90	[illegible]	[illegible]	[illegible]	1.04	1.07	1.11
16	.61	.63	.66	.68	.71	.73	.76	.79	.81	.84	.87	.91	.94	.97	1.01	1.04	1.08	1.11	1.15
16.5	.64	.67	.69	.71	.74	.77	.79	.82	.85	.88	.91	.94	[illegible]	[illegible]	[illegible]	[illegible]	1.12	1.15	1.19
17	.68	.70	.73	.75	.78	.80	.83	.86	.89	.92	.95	[illegible]	[illegible]	1.05	[illegible]	1.12	1.16	1.20	[illegible]
17.5	.71	.74	.76	.79	.81	.84	.87	.90	.93	.96	[illegible]	[illegible]	[illegible]	[illegible]	1.13	1.16	[illegible]	1.24	1.28
18	.75	.77	.80	.82	.85	.88	.91	.94	.97	1.00	[illegible]	1.06	[illegible]	1.13	[illegible]	[illegible]	[illegible]	1.28	1.32
18.5	.79	.81	.84	.86	.89	.92	.95	.98	1.01	1.04	1.07	1.11	1.14	[illegible]	1.21	[illegible]	1.29	[illegible]	1.37
19	.82	.85	.87	.90	.93	.96	.99	1.02	1.05	1.08	1.11	[illegible]	[illegible]	[illegible]	1.26	1.29	1.33	[illegible]	1.41
19.5	.86	.89	.91	.94	.97	1.00	1.03	1.06	[illegible]	[illegible]	1.15	1.19	1.22	[illegible]	[illegible]	[illegible]	1.38	1.42	[illegible]
20	.90	.93	.95	.98	1.01	1.04	1.07	1.10	1.13	1.17	1.20	1.24	[illegible]	[illegible]	[illegible]	1.39	1.43	1.47	1.51

Note. – Calculations by the cone frustum formula.

Formula: $V=0.2618L(\frac{D^2+d^2+dD}{144})$

in which V is the volume, L the length and A_1, A_2 and A_m the two end areas and the middle area respectively. This formula is correct for poles of regular shape or for those either larger or smaller in the middle than at either end.

The second is the mean-end area formula

$$V = \frac{L(A_1 + A_2)}{2}$$

in which V is the volume, L the length, and A_1 and A_2 the two end areas. In this formula the pole is assumed to be a frustum of a paraboloid, but having a basal area equal to the average of the areas of its two ends. Volumes may be more rapidly calculated by this formula, but values are somewhat large for poles other than those which are larger in the middle than at either end.

An Engineer on the I. C. Commission

While the idea is not new, Engineering Council has taken the initiative in suggesting to the President that he appoint an engineer as a member of the Interstate Commerce Commission. This suggestion has much to commend it, not because of the recognition it might give to the engineering profession but because of the opportunity it would afford to give to the Commission the experience and the analytical point of view of one technically trained and familiar with the construction of railways, the relation of standards of construction such as gradients and curvature and of maintenance on operation, and the development of facilities to meet public demands. At present much of the work of the Interstate Commerce Commission is directly or indirectly of an engineering nature. This is particularly true of valuation work but it also applies to the co-ordination of existing facilities and the enlargement of the existing plants to care for growing traffic adequately, etc. If the Commission is to do constructive work in the future in co-operating with the carriers in the development of the transportation system of the country to meet the needs of the traveling and shipping public it will be necessary to give more attention to matters of this character than has been done in the past. At present the personnel of the Commission is drawn principally from the legal profession, while only one of the members has worked for any considerable period on a railway, facts which have frequently been offered as an explanation of its failure to recognize many practical aspects of the railway problem. It has long been contended that an industry as large and as vital to the country's welfare as the railways should be regulated by those who know its problems first hand, just as the administration of the Federal Reserve Banking System is properly in the hands of men trained in the banking business. It should be possible for the President to find engineers in this country of sufficient breadth of vision and knowledge of the public's needs and of first hand acquaintance with the problems of railway management to qualify for such an appointment. Surely they can be found when men such as Goethals and Hoover have been found to meet other needs in public life and men such as Samuel Rea, Julius Kruttschnitt, Samuel M. Felton and W. B. Storey have been promoted from engineering to executive positions on the railways themselves.—Editorial in The Railway Age.

Payment for Estimating.—As a part of its plan for a thorough study of payment for estimating and the development of a fair and practical policy with reference to this important subject, the Associated General Contractors has invited representatives of the American Institute of Architects and the Engineering Council to meet in a joint conference soon.

Observations on Government Housing, and on Town Planning and Housing in General

In an address before the convention of National Association of Real Estate Boards, Atlantic City, June 27, 1919, Mr. William E. Shannon made many definite statements that landscape gardeners and town planners may well take to heart. Incidentally it proves again that we do not have to consult musty European books on the subject or American copies of them; that the ways of the European is not the way of an American; that we have plenty of good examples at home to work upon.

Among other things he said:

The personnel of the United States Housing Corporation was as high as in any bureau of the Government. It was composed of men who were successful leaders in their respective businesses and professions, but, with certain exceptions, amateurs in the business of industrial housing. They were in the main full of theoretical European ideas, always looking to England and Germany for example and not realizing or appreciating the fact that the American-born industrial worker resented being patronized by his employer or subsidized by his Government. With the exception of the secretary, the director and those of the engineering profession they seemed to think more of what Germany had done, and what England was going to do than what America had already accomplished, which made it doubly hard for the experienced realtors to direct them into the right channel.

I also fully realized that our public officials change office with too much rapidity to give a question of this kind (Government control of the home) the solidity of continuous thought and management so necessary to its success. The idea should be rejected in this country because the whole subject properly falls under the local initiative and enterprise as regards time to build, what to build, where to build and terms suitable to the people of that section. A home and its construction and purchase is inherently a local proposition, and can best be handled from beginning to end by the local people. Ours in one of the largest countries in the world stretching 3,000 miles east and west and 1,500 miles north and south, with all the differences in climates and tastes these figures imply, thus giving us here a far more difficult problem to handle than would be the case in England. It is this fact that has brought forth our various types of houses, perhaps not up to the European standard of so-called architectural perfection, but far more comfortable and healthier to live in.

Now as to this beautifully painted picture of European housing, which they (the Housing Bureau) had in mind, and of which so many people write and talk and so few really know about.

I desire to state that the German system would not be permitted by the independent thinking, self-respecting, American workmen to exist in this country. For this country such a system is wrong, the layout is wrong, the design is wrong, and its long payment plan, which in some cases is as much as 50 years, is for no other purpose than to keep the citizens from owning property in fee, for as I was frankly told, "as long as the Government owned the mortgage on a man's home that man would do as bidden." In the question of housing we have nothing to learn from Germany except that which would be bad for our citizenship.

In England I found rather a different state of affairs, the manufacturer taking the place of the Government, but with about the same results. "The Master" with great show appears as if he is desirous of having "his workmen" own their homes, generally in the hollow, while he lives on the hill, but the very small monthly payment spread over years of time keeps the man from securing his home in fee, because death, accident, or a convenient strike throws him out.

The architectural exterior effect seems to be considered by the English philanthropist far more important than the interior comfort. The roof must be just right, otherwise it would be unsightly from his home on the hill. A thatched roof in Ann Hathaway style is considered ideal, though it permits of only a 2x2-ft. bedroom window, but the occupant must not complain—because this is architecturally correct and his cottage has been sold to him at much less than cost, with an interest rate far less than current. A cottage built so close to the ground that it could not have cellar ventilation is raved over as a thing of beauty, though it gives the occupant tuberculosis by living in it.

The street layout of the English "Village Beautiful" for this country is also all wrong. Their design is to have many blocked streets for the purpose of seclusion, and those that are open must be as crooked as possible, even where the topographical features of the land do not demand it.

These so-called "Town Planners" (landscape gardeners of the Bureau) from the appearance of their town designs must have secured their experience in this work from old books on Landscape Architecture published by the monks. Their plans were mostly of the de Medici period, when towns were built for defense, when streets were on angles and curves so they could be defended with the weapons of the day from the rush of invading hordes. They did not appreciate that Benjamin Franklin planned a town in this country not designed for defense, but with straight, broad streets so that God could purify ever corner with His sun and fresh air, and they did not seem to know that later came the great Frenchman, L'Enfant, who assisted by Washington and Jefferson, improved the plan of Philadelphia in the design of the Nation's capital by putting in diagonal avenues. From that date to this America has broken away from the European idea of town planning, and I think it is safe to say we are not going back to it.

I now make the positive statement that whether they are a row, semi-detached or detached homes, this country produces the best built, best ventilated, brightest and most comfortable workmen's homes of any of the nine foreign countries which I have seen, and that this country sells these homes, with rare exceptions, on the safest terms for the occupant's good of any country in the world.

The reason that America produces the best small homes is because America is the only nation that has made it a business to do so. It is in this country that you will find the American homes, homes on top of hills, homes with real windows, wide doors, ventilated cellars, roofs with air space, and modern sanitation; and because of unrestricted competition, at prices that this Government did not and cannot accomplish.

The plan was very simple; merely as a war measure for the Government to release materials to the local builder and through the local banks to assist him in building loans, permitting the local builder to use his characteristic plans as to that individual location; all construction, rents and sales to be conducted by local talent under Government supervision.

This plan being rejected and the so-called up-lift plan of England and Germany being in part adopted as an undefined policy, the next step of the theorist was to start creating separate "ideal villages." These theorists are very able magazine writers and wonderful in getting up Government publications with their names engraved on each plate showing "Architectural Gems" that were never built, as designed.

When one realizes that "ideal villages" meant separate communities requiring additional streets, sewer, water, light, sidewalk, grading and macadam, in fact millions of tons of materials to add to the congestion of the already overburdened railroads of a country at war, and the employment of additional thousands of men for the purpose of installing these utilities when labor was so scarce, you can readily understand why the realtors at the Housing Corporation took the positive position against the architectural and "town planning" divisions of the bureau, that this procedure should not be continued.

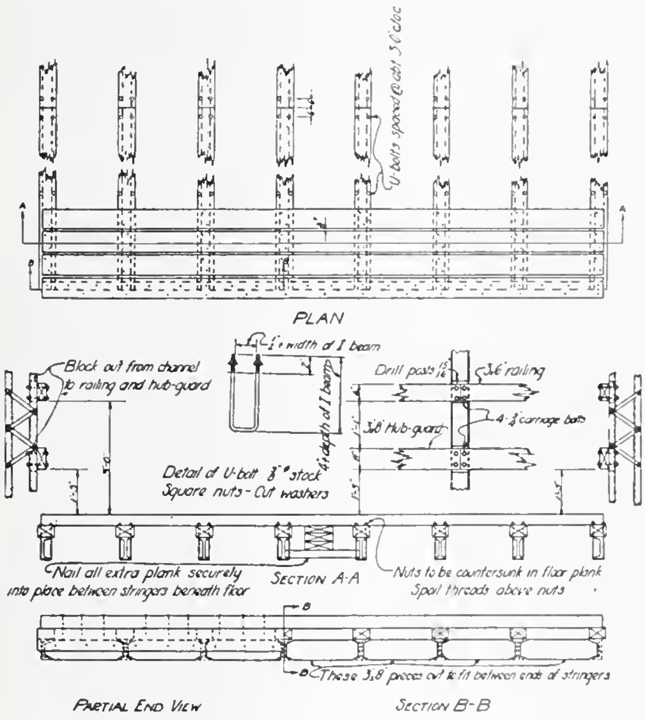
It was by this decision that homes for the industrial war workers were located in select sections away from the "works," but where previously installed transportation systems, schools, churches, amusement and underground utilities were to be found, and the creating of separate villages where workmen and their families were to be isolated under so-called "esthetic surroundings" was discontinued.

I am of the opinion ...., and I know you know that the workmen centers in this country have, with a few possible exceptions, proven a failure. They became known as the "mill town," and that means the American-born industrial worker will not permit his family to live in a "mill town" separated from all except those of his own craft, and he is right in not doing so.

It is proposed to urge Congress to authorize a commission to visit Europe for the purpose of studying the European system of housing with the view of its adoption in this country. I trust Congress in its wisdom will refuse this request, as this recently imported idea is not for the welfare of our Republic.

Plank Floor for Highway Bridges and Railing Hub Guard

Many old bridges on Michigan trunk line highways have been taken over and refloored under the plans of the State Highway Department. This work often required entirely new steel stringers as well as new floor plank. Where new wooden floors are placed, heavy furring strips are first built securely to the top of each stringer. The floor planks are nailed to these furring strips at every intersection. This system, states Mr. C. W. Dewart, Bridge Engineer of the Department, in the 1917-18 biennial report of the State Highway Commission, when properly installed materially reduces the vibration and sway of the trusses and also enables the stringers to carry a much greater load without rupture or turning over. With this construction it has been found advisable to leave off the curbs on the wooden floors and to place a hub guard on the railway. By this plan the floors are kept clean and their life increased. A standard plan of the Department for creosoted plank floor for 18 ft. or less roadway and steel stringers is shown in the accompanying drawing. The bill of lumber for 15-ft. panel and 16-ft. roadway is as follows:


U-bolts spaced @ abt. 3'-0" c/c
PLAN
1" width of I beam
Block out from channel to railing and hub-guard
Drill posts
3x6 railing
3x8 Hub-guard
4-5/8 carriage bolts
depth of I beam
Detail of U-bolt 5/8" stock
Square nuts - Cut washers
Nail all extra plank securely into place between stringers beneath floor
SECTION A-A
Nuts to be countersunk in floor plank
Spoil threads above nuts
B
These 3x8 pieces cut to fit between ends of stringers
PARTIAL END VIEW
SECTION B-B

Standard Plan for Creosoted Plank Floor Showing Hub Guards on Railing.

No.	Size and length	Finish.	Ft. B.M.	Treatment.	Location.	Remarks.
15	3"x12"x16'-0"	Sisie	720	15 lb. creosote.	Flooring . . .	(1)
2	3"x 8"x16'-0"	Sisie	64	None	Hub guard....	(2)
..	3"x 6"x16'-0"	Sisie	..	15 lb. creosote..	Furring strips	(3)
2	3"x 6"x16'-0"	Sisie	48	None	Railing	(4)

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[1] Length equal to width of roadway. [2] Length equal to panel-paint, 3 white coats. [3] One for each stringer. [4] Length equal to panel-paint, 3 white coats.

Method of Facilitating Adjustment of Anchor Bolts.—In setting anchor bolts in the foundation piers for the new viaduct built in connection with the widening of Michigan Ave. in Chicago, the Great Lakes Dredge and Dock Co., contractors, used the following method to provide play in the bolts. A section of old stove pipe 6 in. in diameter and about 8 in. long was placed over each bolt as the concrete was poured. This provided 3-in. play in any direction for each anchor bolt. After the bolts are bent to fit the holes in the steel bearing plate which goes on top of the piers, concrete is placed around the bolts filling the holes made by the pipe, and the bearing plates placed in position.

Herbert Hoover, Engineer*

Here at last we have the example of an engineer who typifies the modern definition of engineering which is thus written in large letters on the wall of the engineers library in New York: "Engineering, the art of organizing and directing men, and controlling forces and materials of Nature for the benefit of the human race." How well this modest mining engineer has shown that he has the art of "organizing and directing men." Of the many thousands working for him, here and abroad, it is said that not only have they given him loyal support, not only are they glad to work for him, but every man of them would take off his coat and fight for him. How well he has shown his capacity for "controlling forces and materials of Nature for the benefit of the human race."

This definition of engineering would have been amazing 40 years ago. The civil engineer was then a surveyor, a mathematician and a bridge designer; the mechanical engineer an educated mechanic, a designer and draught-man; the electrical engineer was unknown outside of the school and the laboratory; while the mining engineer was a combination of the geologist and that kind of a chemist who could tell how much phosphorus there was in a steel rail. I make this statement with apologies to Alexander Holley, who in his day was the one and only mining engineer known beyond the fence of the workshop or mine.

But the engineer is at last coming into his own. We see the dawn of a new day; truly there is a new order of things. The great centers of the world are now industrial centers. The prosperity and strength of nations in peace and war rest now upon the factory system, the shops, the railways and steamships, the mines, the smelters and the public works. And who is responsible for this? Who plans and executes these things? It is the engineer, civil, mining, electrical, mechanical, chemical and automotive. Such captains of industry are by education and experience best fitted to steer the ship of state.

The place for the engineer is not in the dark confines of the hold below, but on the upper deck, yes, on the bridge. We are told that practically all the executive heads of the organization for the relief of Belgium were engineers. Who like an engineer is as well trained by education and experience to meet emergencies? He must be prepared for extraordinary conditions. He must foresee these conditions and be ready to act quickly. A mine manager, usually a mining engineer, when told that a pump has broken down in the mine, cannot wait for the common remedies, but must provide in advance for experts and appliances to be on the spot at once and cure the trouble promptly. Is not this the one thing above all others which enabled America to play so important a part in the war? Was it not the spirit of the engineer, his capacity to do things and do them quickly? Surely the war was not won by money, for the enemy was never financially embarrassed.

I think we shall all agree that the basic strength of the Allies throughout the war was in the never-dying morale of all the people, including the armies, arraigned against Germany. But what would this strength have availed us but for the resources behind the lines. Modern war resources are mainly coal and iron and the capacity to put these things to practical use on a large scale. The mines would avail little but for the works and the works might avail little but for the men, the engineers who direct them on modern, scientific lines of high efficiency.

And so America, through its engineering and industrial strength, helped to save the world from calamity. Now what individual best exemplifies this? Food played an important part in the war. We have heard the cry, that food will win the war. Surely, without food no war could be won. It was Mr. Hoover who took care that there should be no food shortage. He did more—he taught thrift to millions of people in all walks of life and in all parts of the world. He preached the gospel of the clean plate. But it is not only in food that our guest stands as an example of achievement, he typifies the engineer, the executive, the man behind the gun. It is easy to see things that lie directly before us, but the best executive is one who builds his fences around the future who anticipates trouble before it comes.

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*From the speech of William L. Saunders at the "Welcome Home Dinner" given by the Society of Mining and Metallurgical Engineers to Herbert Hoover on Sept. 16 at the Waldorf-Astoria Hotel, New York.

Effect of Vibration, Jigging and Pressure on Concrete*

By DUFF A. ABRAMS.

Professor in Charge, Structural Materials Research Laboratory, Lewis Institute, Chicago.

An experimental study of the effect of vibration and pressure on fresh concrete—on its strength and other properties—is of interest, in view of the frequent use of such devices as hand-hammering of forms, or air-hammering, jigging or vibration as an aid in placing concrete. Such methods are particularly applicable to the construction of reinforced concrete ships and houses, where thin sections and a multiplicity of reinforcing members are of common occurrence. Jigging or vibrating machines are frequently used in concrete products plants. The effect of pressure on fresh concrete is important in certain problems of concrete design.

These tests were made as a part of the experimental studies of concrete and concrete materials, being carried out through the co-operation of Lewis Institute and the Portland Cement Association. The series included 600 compression tests of 6-in. x 12-in. concrete cylinders at the age of 28 days. All specimens were made from the same materials at the same time, consequently direct comparisons may be made between any two sets of tests.

The portland cement used consisted of a mixture of equal parts of four brands purchased from Chicago dealers. The cement conformed to all the requirements of the Standard Specifications and Tests for portland cement of the American Society for Testing Materials.

In general the aggregates consisted of sand and pebbles from the Chicago Gravel Co.'s pit near Elgin, Ill. In one group of tests crushed limestone was used as coarse aggregate. Sieve analysis and miscellaneous tests of aggregates are given in Table I.

The "fineness modulus" of an aggregate may be used as a measure of its size and grading. It is the sum of the percentages in the sieve analysis divided by 100.

The sieve analysis is expressed in terms of weight or volume coarser than each of the Tyler standard screen sieves which were used. The sizes of sieves and fineness modulus of the aggregates are also shown in Table 1. Low values of fineness modulus correspond to small size and high values to the coarse sizes of aggregate.

Test Specimens.—All test pieces used in the tests consisted of 6-in. x 12-in. cylinders which were stored in damp sand for 28 days. The concrete for each specimen was proportioned separately and mixed by hand with a bricklayer's trowel, in a shallow metal pan. The forms consisted of 12-in. lengths of cold-drawn steel tubing, split along one element. Each form stood on a machined cast-iron base plate. A smooth top was formed by means of neat cement and plate glass.

Unless otherwise noted, the specimens were molded by the "standard" hand-puddling method before subjecting them to vibration, jigging or pressure. This method consists of puddling the fresh concrete in the metal form in 4-in. layers by means of 25 strokes with a ⅝-in. round steel bar and leveling off with a trowel. This method has been in use for several years in our research work and has been found to give uniform results for different operators. The strength of the concrete produced by this method of molding is used as a basis for comparison for all other methods of treatment included in this investigation.

The mixture is expressed as one volume of cement to a given number of volumes of mixed aggregate. A 1:5 mix expressed in this manner is about the same as the ordinary 1:2:4 mix. The exact equivalent of the latter will vary with the size and grading of the aggregates.

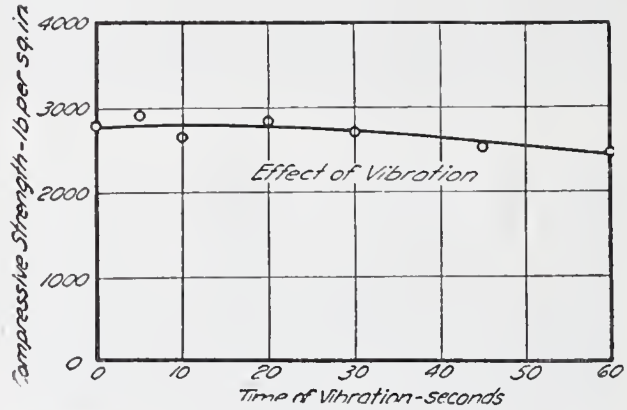

Fig. 1.—Effect of Vibration Produced by Electric Motor on Strength of Concrete.

The water content of the concrete is expressed in terms of the relative consistency and the "water-ratio." A relative consistency of 1.00 (normal consistency) is of such plasticity that the concrete of usual mixes will slump ½ in. to 1 in. if the metal form is withdrawn by a steady upward pull immediately after molding the cylinder by the standard method. A relative consistency of 1.10 contains 10 per cent more water than normal consistency. The water-ratio is the ratio of volume of water to volume of cement in the batch. The weight of cement was assumed as 94 lb. per cubic foot. For one mix and given concrete materials the relative consistency and water-ratio may be used interchangeably.

In the hand-molded specimens the method of placing the concrete was varied by changing the number of strokes of the puddling bar, using layers of different thickness, etc. Hand-tampers 2 in. and 5 in. in diameter were also used. In one set of tests the form was struck with a steel bar after molding by the standard puddling method.

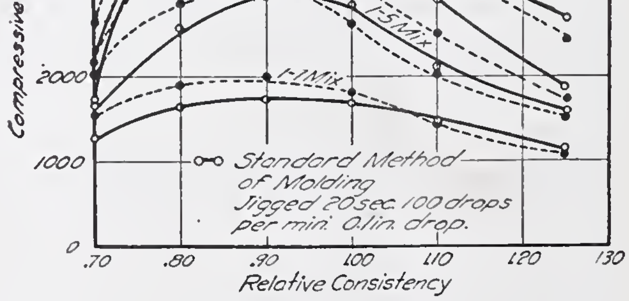

Fig. 2.—Effect of Consistency on Strength of Jigged Concrete.

Methods of Making Test.—In the vibration tests the cylinder mold was bolted to a light timber table and the concrete specimen molded by the standard hand-puddling method described above.

Violent vibration was produced by holding a small electric motor frame against the side of the steel form containing the

TABLE I.—MISCELLANEOUS TESTS OF AGGREGATE.

Size.	Kind.	Weight, lb. per cu. ft.	Density.	Sieve analysis of aggregate (per cent coarser than each sieve). 100	48	28	14	8	4	⅜"	¾"	1½"	Fineness modulus.*
0-28		102	0.61	88	42	0	..	..	..	..	..	..	1.20
0-14	Elgin	104	0.62	90	91	36	0	..	..	..	..	..	2.25
0-8	Sand	108	0.65	99	92	50	22	0	..	..	..	..	2.64
0-4	and	112	0.67	99	94	59	36	18	0	..	..	..	3.06
0-⅜ in.	Pebbles	120	0.72	99	96	73	57	16	33	0	..	..	4.04
0-¾ in.		124	0.74	99	97	82	72	64	58	30	0	..	5.02
0-1½ in.		128	0.77	99	98	87	80	75	68	18	20	0	5.75
	Elgin	119	0.71	99	95	69	51	38	24	17	7	0	4.00
	Sand	125	0.75	99	97	79	68	58	49	35	15	0	5.00
0-1½ in.	and	126	0.76	99	98	85	76	69	62	43	18	0	5.50
	Pebbles	128	0.77	99	98	87	80	75	68	48	20	0	5.75
		128	0.77	100	98	90	84	79	75	52	22	0	6.00
		125	0.75	100	99	92	88	84	81	57	24	0	6.25
		120	0.72	100	99	95	92	90	87	62	25	0	6.50
	Elgin	123	0.74	99	95	69	51	38	24	17	7	0	4.00
	Sand	128	0.77	99	97	79	68	58	49	35	15	0	5.00
0-1½ in.	and	124	0.74	99	98	85	76	69	62	43	18	0	5.50
	Crushed	122	0.73	99	98	87	80	75	68	48	20	0	5.75
	Lime-	118	0.71	100	98	90	84	79	75	52	22	0	6.00
	stone	114	0.68	100	99	92	88	84	81	57	24	0	6.25
		110	0.66	100	99	95	92	90	87	62	25	0	6.50

*The sum of percentages in sieve analysis, divided by 100.

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*From a paper presented at the annual meeting of American Concrete Institute, June, 1919.

concrete mixture. The motor carried an eccentric flywheel, weighed 12 lb., and ran about 1,000 r.p.m. The time of vibration varied from 5 seconds to 1 minute.

The jigging tests were made on a machine which consisted of a framework carrying a metal table about 4 ft. wide and 8 ft. long, weighing about 700 lb. The table was raised by means of belt-driven cams on two longitudinal shafts. The rate and height of drop could be varied over a wide range.

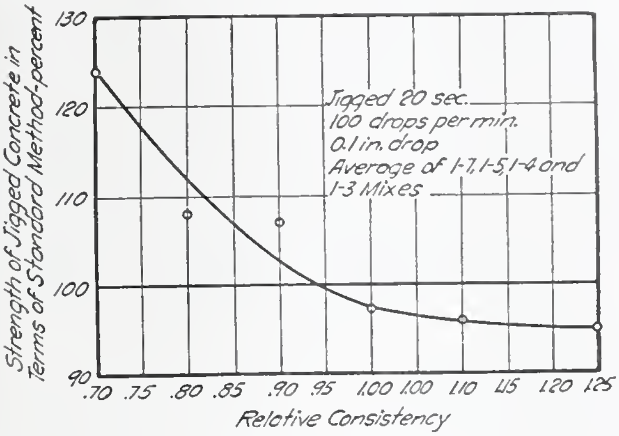

Fig. 3.—Effect of Consistency on Strength of Jigged Concrete. Each Value is Average of 20 Tests.

In most of the tests the machine was run for 20 seconds at 100 drops per minute, 0.1 in. drops. However, each of these factors were varied with the other two constant.

All specimens were molded by the standard hand-puddling method before pressure was applied. Pressures up to 10 lb. per square inch were obtained by piling weights on top of a loose-fitting cover plate. Pressures of 25 lb. and 50 lb. per square inch were applied by weighted levers. Pressures of 100 lb. to 500 lb. per square inch were obtained by placing the freshly molded specimen in a testing machine. The spring facilitated maintaining a constant pressure. For all pressures the time of application varied from 15 minutes to 16 hours.

The metal forms were fairly tight and permitted little leakage of water under ordinary conditions. For the wetter concretes the joints were scaled with paraffin. In the pressure tests the water expelled was collected by means of sponges and weighed. It should be noted that this water was almost clear.

Test cylinders were made in sets of five on different days. One specimen of each form was made before starting the second round. The strengths platted in curves are the average of five entirely independent tests. In this way minor variations in materials, proportions, manipulation, etc., are eliminated. In the case of the "standard" hand-puddled specimens which are used as a basis of comparison, three sets of five specimens were made in different parts of the series.

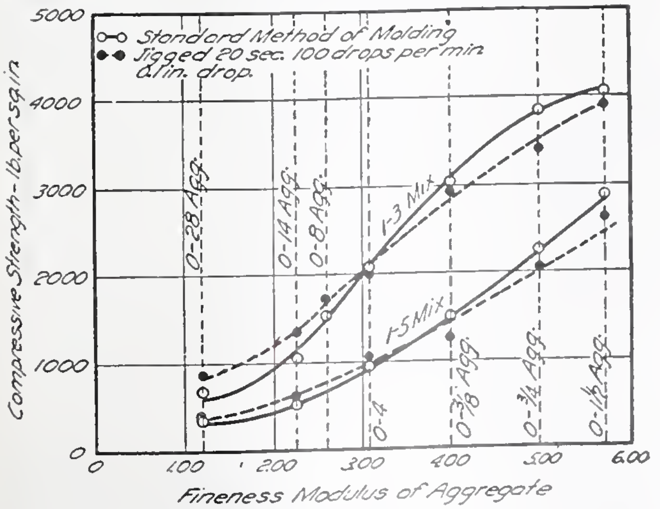

Fig. 4.—Effect of Size of Aggregate on Strength of Jigged Concrete.

Data from the Tests.—Most of the data of the tests will be found platted in graphical form in the illustrations. Other results are taken up in the conclusions that were drawn. Only average values are reported. It will be noted that the "standard" hand-puddled concrete (average of 15 tests) is used as the basis of comparison.

A comparison of the relative effects of puddling 1:5 plastic concrete with a steel bar and tamping with tampers of different weight and size is given in Table II.

The effect of vibration with electric vibrator is shown in Fig. 1. Vibrating for about 30 seconds caused no appreciable effect on the strength of concrete which had been pudaled in place by hand. The tests indicate that hand puddling (if thoroughly done) is just as effective as vibration in placing concrete. In other words, concrete which completely fills the form is not improved by vibration. This should not, however, be construed as meaning that vibration is not effective in causing concrete to find its way into intricate form work and around the reinforcing bars.

The effect of jigging is shown in Figs. 2 to 5. The jigging method used was one which would be applicable to concrete products plants. The tests show that in general, jigging of concrete which has been placed by puddling is injurious to the strength. The improvement for the small-sized aggregates is probably due to the fact that the puddling method is not so satisfactory for this condition.

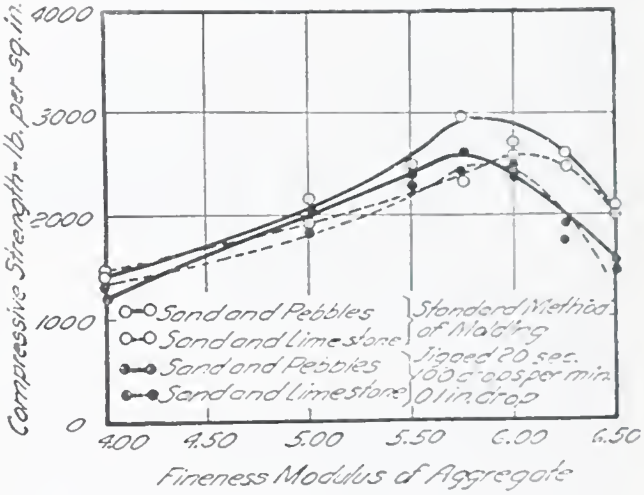

Fig. 5.—Effect of Grading of Aggregate on Strength of Jigged Concrete.

TABLE II.—EFFECT OF PUDDLING AND TAMPING CONCRETE SPECIMENS.

Mix by volume.	Water-ratio to volume of cement.	Compressive strength. Per cent of standard.	Compressive strength. Lb. per sq. inch.	Treatment of concrete.
1:5	0.875	2680	96	12 strokes around perimeter form for each 4-in. layer of concrete, using 5/8-in. steel bar.
1:5	. . .	2800	100	25 strokes distributed over section for each 4-in. layer, using 5/8-in. steel bar. (Standard method.)
1:5	. . .	2710	. . .	
1:5	. . .	2840	. . .	
		2780*		
1:5	. . .	2810	101	50 strokes distributed over section for each 4-in. layer, using 5/8-in. bar.
1:5		2690	97	12 strokes on each 4-in. layer, using 2-lb. tamper 2 in. in diameter.
1:5		2420	87	12 strokes on each 6-in. layer, using 2-lb. 2-in. tamper.
1:5		2430	87	12 strokes on first 3-in. layer, using 2-lb. 2-in. tamper, form then filled before tamping again with 12 strokes.
1:5		2500	90	12 strokes on first 3-in. layer using 2-lb. 2-in. tamper, remaining concrete settled by tapping form lightly.
1:5	. . .	2800	101	25 strokes distributed over section for each 4-in. layer with 2-lb. 2 in. tamper.
1:5		2570	92	25 strokes distributed over section for each 4-in. layer with 2-lb. [illegible]-in. tamper.
1:5	. . .	2740	98	Standard method of molding, except form struck 3 light blows with steel bar after puddling each 4-in. layer.

Compression tests of 6-in. x 12-in. cylinders.
Age of test, 28 days; stored in damp sand; tested damp.
Aggregate—Sand and pebbles from Elgin, Ill., graded [illegible]-1½ in.
Each value is the average of 5 tests made on different days.
Fineness modulus of aggregate—5.75.
Relative consistency—1.00.
*This value is used as a basis for comparison in the data that we obtained, and in the curves shown.

The tests of concrete setting under pressure are of interest in that they reveal the reason for increased strength due to this treatment. The concrete strength is increased due to the fact that some of the original mixing water is forced out. The higher the pressure, the more water is removed, hence the higher the strength.

Summary and Conclusions.—The tests gave conclusive results on many phases of the effect of vibration, jigging and pressure. In some instances the effect is entirely different from what accepted opinion would suggest. A brief summary of the tests follows:

Varying the number of strokes from 12 to 50 on each 4-in. layer in the standard method of hand-puddling with a ⅝-in. bar had little influence on the compressive strength of ordinary plastic concrete.

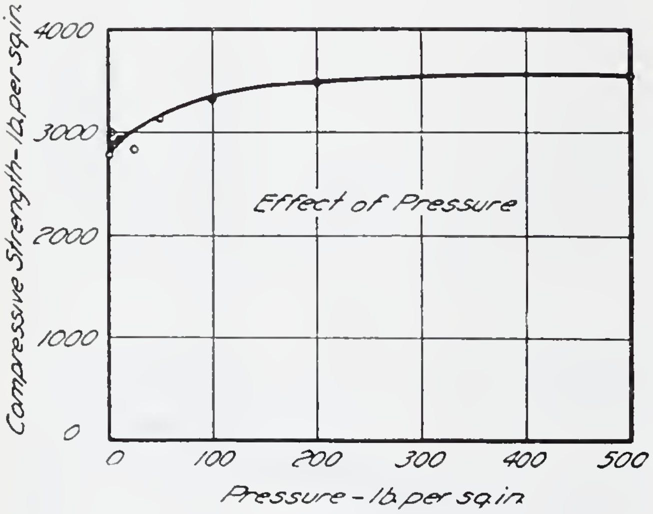

Fig. 6.—Effect of Pressure on Strength of Concrete.

In general, the tamping methods used gave lower strengths than hand-puddling.

A tamper of large diameter for a given weight was less effective than one of smaller diameter.

Increasing the thickness of the layer from 4 in. to 6 in. caused a falling off in strength of about 12 per cent for tamped concrete.

Tamping or puddling the first 4-in. layer only, caused a falling off in strength of 10 per cent to 13 per cent.

Striking the metal form with a steel bar after the completion of molding by standard method had no effect on the strength of concrete.

The "standard" method of hand-puddling, using 25 strokes with a ⅝-in. steel bar for each 4-in. layer of concrete in a 6-in. x 12-in. cylinder, is recommended for laboratory tests of concrete.

Vibration of the specimen after molding by means of an electric hammer running at 1,000 r.p.m. had little influence on the strength of the puddled concrete up to a period of about 30 seconds. If continued, there was a steady falling off in strength; after 45 to 60 seconds the strength was only 90 per cent of that produced by the standard method of puddling.

In general, jigging in any manner with the apparatus used reduced the compressive strength of the concrete regardless of the height of drop, rate or duration of treatment. Exceptions were found in the dry mixes and those made of aggregates of the smaller sizes.

There was little difference in the effect of jigging due to the quantity of cement used.

In the very dry mixes the strength, due to jigging 20 seconds, was increased about 25 per cent.

The wetter mixes (relative consistency 1.10 to 1.25) were reduced in strength 3 per cent to 6 per cent by jigging.

Pebbles and crushed limestone as coarse aggregate gave essentially the same results in the jigging tests.

The concretes for finer aggregates showed a material increase in strength with jigging in both 1:5 and 1:3 mixes.

For aggregate coarser than about ⅜ in., jigging reduced the strength from 3 per cent to 10 per cent.

The grading of the aggregates (for a given maximum size) had little influence on the effect of jigging.

The greater the drop the greater the reduction in strength for 1:5 concrete. For a drop of ½ in. the strength was reduced 12 per cent.

The faster the rate of jigging the lower strength of 1:5 concrete. Using 1½-in. aggregate at 150 r.p.m. the strength was reduced about 13 per cent.

The strength of 1:5 concrete fell off rapidly with the duration of jigging. After 2 to 3 minutes jigging the strength was reduced about 20 per cent as compared with standard method of hand-puddling.

Allowing the concrete to stand for a period of time before jigging increased the strength to a slight extent. The maximum increase was found at 2 hours to 4 hours.

The application of a pressure of 1 lb. per square inch during the jigging process (equivalent to a head of 1 ft. of fresh concrete) gave the same strength as standard hand-puddling.

Molding the cylinders by the standard method on the jigging table while it was in motion, gave the same strength as standard hand-puddling without jigging.

The compressive strength of concrete was increased by pressure applied immediately after molding. For pressure of 200 to 500 lb. per square inch the increase was 20 per cent to 35 per cent.

The duration of pressure as between 15 minutes and 16 hours produced no difference in strength.

There was a steady reduction in the water-ratio of the concrete with the application of pressure.

The application of pressure increased the strength of concrete in accordance with the quantity of mixing water expelled.

The tests of concrete subjected to pressure showed the usual relation between compressive strength and water-ratio. The strength is increased because the water is expelled. In other words, pressure produces a drier concrete, and consequently gives higher strength. This makes it clear why the duration of pressure has no influence on the result.

The indications of the vibrations and jigging tests should not be misinterpreted. The tests show that after the concrete is properly placed these methods of treatment do no good and may be harmful if too severe or too long continued. However, there can be no doubt of the value of such methods for getting concrete into place in intricate forms and around reinforcing bars. The tests are of value in showing that this is the only desirable function of such treatments. The eighth test series in Table II shows the ill effects of lack of compactness in the concrete. Here the strength was reduced 13 per cent, due to failure to tamp or puddle the top 9 in. of the cylinder. It is impracticable to duplicate in a compression test piece the performance of air hammers and other similar methods of vibrating when used on reinforced concrete work.

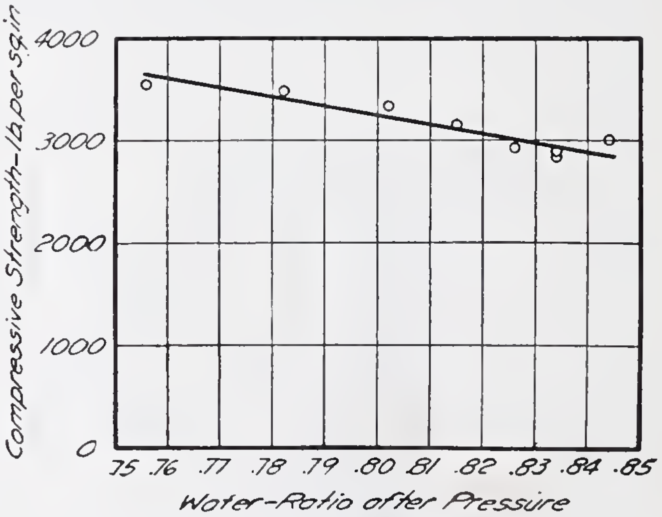

Fig. 7.—Effect of Quantity of Mixing Water on Strength of Concrete.

The tests show that with jigging high strength may be secured with drier mixes than would be feasible otherwise. It is a matter of common experience that concrete of drier consistency (and consequently higher strength) can be placed by means of jigging or vibration than would be possible by the usual methods.

Building Construction Under the Cost-Plus-Fixed-Fee Contract

By A. E. WELLS
President Wells Brothers Construction Co., Chicago.

If a half dozen street urchins are caught by a burly representative of the law while engaged in the pastime of shooting craps, the law against gambling acts. Law makers have recognized that gambling is an unnecessary evil and have, so far as possible, put a stop to it. Yet an owner and a contractor can gamble with a million times the stake of the street urchins without fear of the law and it is done constantly under the guise of the lump-sum contract.

For under its terms the contractor agrees that for a certain sum of money he will guarantee the owner against all the unknown conditions involved in putting up a structure. Whether he makes his figured profit or whether he loses so heavily as to be put out of business rests partly on his ability to figure costs, but largely on his luck in failing to meet those conditions which would increase costs.

Both parties to this contract stand to gain or lose. If the job costs 20 per cent more than estimated the owner gains to the other's loss. If conditions make considerable saving possible, then the contractor gains to the owner's loss.

Many contractors who in times past have built extensively in our field are no longer operating. Others have taken their place. Perhaps the majority of the missing firms are those who were expected not only to build according to specifications and within the time limit, but to gamble that their costs would fall within a fixed contract price. Gambling against variables such as the forces of nature and the conditions of labor—they lost. In many cases their failure involved an added investment on the part of the owner or possibly the surety company. It is certain that no one gained through the failure.

The contractor is an expert retained to assemble certain materials into a finished structure. The question being asked today is "should the contractor insure the owner that his structure will not exceed a definite contract price." In competitive bidding the cost of this insurance is paid generally by the low bidder out of profits or, as frequently happens, out of his capital, for the reason that he is more likely to get the contract as he scales down his allowance for contingencies. In fact, the man whose bid includes a safe allowance for insurance against higher costs cannot expect to obtain work under the competitive bidding system. The inevitable result is the bankruptcy of many contractors and an additional cost to the owner or the surety company to complete the unfinished contract. This situation has come to such a point that surety companies are refusing to write surety bonds on fixed price contracts except under specially favorable conditions and frequently recommend to owners the cost-plus-a-fixed-fee contract.

But from the owner's standpoint is it not preferable to know in advance what a certain project will cost? It is true that a careful estimate is due him. It should be made by a reliable contractor and checked by owner's architect and engineer. Such a figure should be more satisfactory than a competitive bid which does not necessarily show the cost of the building but only what some contractor is willing to gamble is the cost of the job.

An issue of bonds for an office building or other structure can as well be based upon a careful preliminary estimate in either case. It can only run below the estimate under the cost-plus-fixed-fee plan. Is not the owner entitled to the possible saving?

Additional financing may be an unfortunate necessity but is there reason why the contractor should be asked to under-write the accident of greater cost?

At the Chicago meeting of the Associated General Contractors of America, Nov. 21, 1918, this type was discussed and Brigadier-General R. C. Marshall, Jr., chief of the construction division of the U. S. War Department, pointed out the fault of the usual pre-war basis of contract. He showed the impossibility on recent War Department work of asking for competitive bids, because speed was the essence and detailed plans and specifications were never complete at the time when construction must start. On such work it was, therefore, out of the question for a contractor to bid on a flat contract price basis. It would not have been fair to either side. As a result there was developed a form of contract known as the cost-plus-sliding-scale-fee contract.

General Marshall said that early in the spring of 1918 the program of work before the construction division was so extensive that it seemed advisable to have the merits of this form of contract again passed upon and a committee of eminent business men unqualifiedly endorsed this form of contract. In General Marshall's own words at the convention of general contractors:

"No contractor should be called upon nor permitted to undertake the performance of any contract that within the four corners of the paper upon which it appears is, or may be written the financial bankruptcy of the contractor. It is unjust, it is inequitable, it is uneconomic. The great lesson of this war on the subject of the relationship between the contractor and the owner is the cost-plus contract. This represents the only equitable basis under which a contractor may perform constructive and economic services for the owner. It is the only form of contract which affords protection to both parties. To me all the energies, the thought and the experience of this country within its own continental lines during the past year and one-half of this world struggle shall have been in vain unless out of it shall grow, as a permanent institution, solidifying the economic relationship between the contractor and owner, the cost plus contract."

We have been operating under this plan almost exclusively for several years. We know that it is possible to convince most business men of the perfect fairness of the cost-plus contract and among our clients are several who would be the last to tie themselves up with us on any basis of contract likely to be unfair or dangerous. We have built on this basis for Montgomery Ward & Co., four successive times, for the Robert Simpson Co., Ltd. Toronto, five separate buildings and for the William Davies Co., Ltd., Toronto, six buildings. For these firms we have been able to start actual construction much earlier than otherwise would have been possible, which means early occupancy. The reason for this is that we can start the foundations just as quickly as the foundation plans are complete and further design and construction may go on coincidentally.

Money tied up during construction earns nothing until the building is ready for occupancy and the interest often amounts to a considerable sum. When we have opportunity to work with the owner, architect and engineer from the very inception of plans and when we begin foundations as soon as the general contour of the building and equipment are determined upon, we are able materially to cut down the period during which the owner's capital is unproductive. Under the lump-sum contract it is necessary that the plans be complete before bids are taken, which may delay occupancy for months and without occupancy a building investment is poor as a dividend producer.

But while speed is of first importance in most building contracts, yet fairness to both parties is an equally good reason for its general adoption and on that basis our company is now operating almost exclusively. We feel that the owner should reap any benefit we are able to bring about. To give us incentive to make such savings we ask a moderate percentage of that saving under the estimated cost. Our standard contract calls for a return to the owner of 90 per cent of such savings, all of which would have accrued wholly to the contractor under the lump-sum plan. We believe 10 per cent of the savings to be an adequate incentive for the contractor. We have almost invariably made savings for the owner below the estimated cost on our cost plus contracts and such savings have not been through the padding of preliminary estimates but through changes or economies in construction made with the consent of owner, architect and engineer, which produced either a structure more adaptable to its purpose or of lower cost with equal value. Such changes could be made only with difficulty under the lump-sum contract, as the average owner is averse to changing original specifications because of the generally high cost of "extras" or divergence from the original basis of bidding.

The cost-plus-fixed-fee basis has been adopted for the major manufacturing and merchandising operations. Automobile makers do not gamble with a fixed price, but from season to season vary their selling prices according as costs rise or fall. There is less of general price advertising than before the war and now many standard articles of commerce, once fixed as to price like the Ingersoll dollar watch, are today on a new basis and tomorrow may be higher or lower according as costs dictate.

Preliminary Work for Construction of 1,000 Ft. Concrete Arch at Montgomery, Pa.

In preparing for the construction of a reinforced concrete arch bridge over the West Branch of the Susquehanna river at Montgomery, Pa., the contractors were confronted with a variety of problems.

It was desirable, in the interest of economy, to obtain the gravel from the river bed and to separate the sand from the gravel, and to carry the waste sand to an approach fill which was a part of the work. Some of the gravel was oversize for concrete and required crushing.

Barge and River Trestle.

Sand was obtainable from a local bank about ½ mile from the work and could be transported directly by dump cars to the foot of the bins.

To do the river work two derrick barges were built. Each barge consisted of a pair of barges, 14 ft. by 42 ft., strengthened with three solid longitudinal bulkheads. These twin barges were fastened together, with 2 ft. separation, making a barge 30 ft. by 42 ft., and equipped with hoisting engine, swinging engine, clam shell bucket and centrifugal pump.

Sixty-foot booms were used and a trestle built across the river parallel to the bridge site and 67 ft. from the center line. One track from the trestle led to the mixer and another to a trestle from which the sand and gravel were dumped.

Crusher, Elevator, Stone Bin, Material Trestle and Hopper.

The gravel and sand bin was placed directly on a line with the trestle across the river. The bin is a four-story structure, 16 ft. by 24 ft. and 50 ft. high. On the extreme top is a revolving screen, 12 ft. long, fed by a 60 ft. elevator. From this screen the sand and gravel are carried by chutes into their respective bins. Directly under the bins is the mixing floor. In the center is a steel measuring box which is charged by chutes from the bins. Cement is carried to this floor from a cement house adjoining, by an inclined track, a small car hauled by wire rope furnishing the transportation means.

The base of the measuring box discharges directly into the mixer and the mixer dumps directly into buckets waiting on track adjacent, from whence the concrete is moved to the trestle and placed in the forms by the derrick barge. The mixer is a 1-yd. cube mixer, steam driven.

A 10-ton locomotive crane, equipped with clam-shell, handles all material after it is dumped from the material trestle. The material is placed in a hopper 8 ft. square, about 20 ft. above the ground. If it is desired to wash out the sand, water is turned on, which attacks the sand as it is leaving the hopper, and water and sand pass through a grating of parallel bars and into a trough and thence to the fill. The balance of the material is carried to the crusher and fed into the elevator and carried to the top of the bins. Power for the crusher and elevator is supplied by a 30 hp. electric motor. If it is not desired to wash out the sand the operation is the same, excepting that no water is supplied and the bars are covered with a steel plate and all material, both sand and gravel, passes through the crusher.

The following tabulations, adapted from the rule book of ing County, Pennsylvania. It is 1,028 ft. long, with nine arches and "U" shaped abutments. Each arch has two ribs, carrying spandrel walls and supporting a slab roadway, paved with wood blocks. Provision is made for future trolley track. Gas and electric mains will be part of the structure and ornamental light fixtures on pylons at the piers are part of the decorative scheme. The bridge was designed by Mark C. Krause, Consulting Engineer, Williamsport, Pa. The contractor is the Walter R. Cliffe Co., Philadelphia, Pa. Capt. Frank C. Smythe is engineer for the contractor.

Safe Loads on Planks and Timbers for Scaffolds, Falsework and Other Structures

The following tabulations, adapted from the rule book of the McClintic-Marshall Construction Co. have been issued by the Construction Section of the National Safety Council, to show the loads that may be carried safely on planks and timbers in scaffolds, falsework and other structures. The loads are for yellow pine in good condition. For timber of poorer grades the loads must be reduced:

SAFE LOADS (IN TONS) ON TIMBER USED AS A COLUMN, POST OR BRACE.

	Length in Feet.											
Size.	6	8	10	12	16	20	24	28	32	40	50	60
4x 4	9	7	6	5	2							
6x 6	29	21	19	17	13	9	5					
8x 8	51	51	51	36	30	25	20	15	10			
10x10	80	80	80	80	54	48	41	35	29	16		
12x12	115	115	115	115	85	77	69	61	54	38	19	
14x14	156	156	156	156	156	112	102	94	85	67	45	22

The unit stress allowed is 1,600 (1-1/60d), with maximum stress 1,200.

SAFE LOADS (IN POUNDS) ON PLANK FOR SCAFFOLDS, ETC.

	Span in Feet.										
Size.	4	6	8	10	12	14	16	18	20	22	24
2x10	870	570	415	310	250	200	165				
2x12	1,000	680	500	370	300	240	200	155			
3x14	2,400	1,560	1,150	900	720	600	500	420	350	300	250

These are safe loads concentrated at center of span. For uniformly distributed loads, the figures may be doubled. Unit stress 1,600.

SAFE LOADS (IN POUNDS) ON TIMBER USED AS A BEAM.

	Span in Feet.									
Size.	4	6	8	10	12	14	16	18	20	24
2x 4.	705	465	340	270	220	180	155			
4x 4.	1,410	930	680	550	440	390	310			
4x 6.	3,200	2,100	1,560	1,249	1,030	860	730	640	560	
6x 6.	4,800	3,200	2,360	1,850	1,550	1,300	1,100	960	840	
6x 8.	8,500	5,650	4,200	3,340	2,750	2,320	2,000	1,750	1,540	1,220
8x 8.	11,300	7,500	5,600	4,450	3,660	3,100	2,660	2,330	2,060	1,639
8x12.	19,100	16,900	12,600	10,000	8,200	7,100	6,100	5,400	4,800	3,800
8x14.	22,200	22,100	17,300	13,700	11,400	9,600	8,400	7,400	6,500	5,300
8x16.	25,400	25,300	22,600	18,000	14,900	12,700	11,000	9,800	8,600	7,000
10x10.	19,800	14,600	11,000	8,700	7,200	6,100	5,300	4,600	4,100	3,300
10x12.	23,800	21,000	15,800	12,500	10,400	8,900	7,600	6,700	6,000	4,800
10x14.	27,800	27,700	21,600	17,200	14,200	12,100	10,500	9,200	8,200	6,600
12x12.	28,600	25,400	19,000	15,000	12,500	10,600	9,200	8,100	7,200	5,800
12x14.	33,400	33,200	25,900	20,600	17,000	14,500	12,600	11,000	9,800	7,900
12x16.	38,200	38,000	33,700	27,000	22,300	19,000	16,500	14,600	13,000	10,500
14x14.	39,000	38,800	30,200	24,000	19,900	17,000	14,700	12,900	11,500	9,350

These are safe loads concentrated at center of span. For uniformly distributed loads, the figures may be doubled, but must not exceed the values given in the table under "span 4 ft." Unit stress 1,600.

Chicago Carpenters' Strike Settled.—The carpenters' strike which has tied up building operations in Chicago for the past 10 weeks, was settled Sept. 19 and the men returned to work Sept. 22. The demand of the carpenters for a wage of $1 per hour was granted. The agreement provides that no further change in wages of these men is to take effect prior to June 1, 1920.

Fatigue Phenomena in Metals

The phenomena of fatigue failure have recently given rise to some perplexing problems in connection with the design and service of airplane-engine crankshafts, the hulls of steel ships, axles and shafts in railway cars, motor cars and trucks, and other machine parts. The question whether structural parts subjected to repeated stress are in danger of fatigue failure has been discussed at considerable length. The danger of fatigue failure seems to be an unimportant factor in determining the safety of structural parts, with the possible exception of parts subjected to reversal of stress. The reason for this is probably found in the relatively small number of loadings which most structures are called upon to withstand, and in the fact that most of the loadings are below the maximum working value. On the other hand, the danger of fatigue failure is a major factor in determining the safety of many machine parts.

In a progress report printed in the September Journal of the American Society of Mechanical Engineers, the committee on Fatigue Phenomena in Metals, which is acting under the joint auspices of the Engineering Foundation and the Division of Engineering of the National Research Council, gives an interesting summary of the available facts and theories relating to fatigue failure. The matter following is abstracted from the report.

The problem of fatigue of metals engaged the attention of engineers 70 years ago, in connection with car axles and members of iron railway bridges. In these earlier experiments several facts seem noteworthy. The prime object of the investigators was to deduce laws of fatigue for railway bridges and car axles. The problem of fatigue in high-speed machine parts had not then appeared. These investigators carried their tests far enough to cover the number of repetitions required by the structures of their day and assumed that having done so they had established an endurance limit. Reading their conclusions carefully, the statement does not seem to be made that material which passed their tests would stand an infinite number of repetitions. The term generally used is "indefinite" or "very large," and the number corresponding is from 10,000,000 to 50,000,000. For the problem which they investigated their tests seem to give safe guides for practice, but today, with the advent of modern high-speed machinery, some parts of which must be as light as possible, and the extension of the fatigue problem to such members as the cranks and the connecting rods of gas engines and the shafts of steam turbines, the number of repetitions of stress which a machine member may be called upon to undergo is very much increased. This fact is illustrated by Table I, which gives a statement of the approximate service required from various structural and machine members.

The Phenomena of Fatigue Failure.—A fatigue failure of a metal, whether it occurs in a test specimen or in a machine part, is characterized by suddenness, lack of warning, apparent brittleness of material, and, in many cases, a fracture with a crystalline appearance over a part of its surface.

This crystalline appearance led to the old theory that under repeated stress metal "crystallized," changing from a ductile "fibrous" structure to a brittle "crystalline" one. This theory, however, has been quite thoroughly demolished as a result of study of the structure of steel under the microscope. As revealed by the microscope the structure of all metals used for structures and machines is crystalline, any "fibrous" structure being caused by inclusions of non-metallic impurities (for example, slag in wrought iron). Microscopic examination of metals under stress shows no change of the general scheme of internal structure, but under sufficiently heavy stress there appears gradual breakdown of the crystals in the structure.

When a ductile metal is deformed cold the first deformation occurs in the particular grains which either take the most stress or have the lowest elastic limit. Deformation takes place by the slipping of one portion of the grain with reference to other portions. This slipping is shown by the appearance of lines called "slip bands" or "slip lines" extending across crystals and indicating planes of cleavage. As the load is increased deformation proceeds and other slip bands are formed, the law being that the most easily deformable grains first show slip bands. Gradually the most favorable planes of slip are exhausted, and further slippage can take place only with the addition of more load.

The failure in ductile metals subjected to repeated stress takes place with substantially no general deformation. There is, however, considerable local deformation over microscopic areas, evidenced by the appearance of many slip bands on a polished surface of the metal after the application of repeated stress. These slip bands appear after a small number of reversals of stress with relatively large loads, and may not appear at all with slight loads. The slip bands may first appear either in the interior of a grain or at the grain boundary. As the number of applications of stress increases more slip bands appear, and those first appearing usually lengthen and widen. Under the microscope and with normal illumination the general surface becomes blacker as the number and width of the slip bands increase. In ductile metals fatigue failure is almost exclusively through the grains themselves rather than at the grain boundaries, and the first slip bands to appear do not necessarily form a part of the final path of rupture. Failure seems to take place by the uniting of slip bands into cracks. When the first grain develops a crack extending across its entire width, added stress promotes the extension of this crack into adjacent grains on both sides, although the orientations of these grains may be and usually are such that the crack must extend itself at an angle to that in the initial grain. The general tendency is for these slip bands to follow the lines of cleavage of the particular grain in which they occur. Often incipient fracture is found in many grains adjacent to the final path of rupture, indicating that had rupture not taken place where it did, it would have soon taken place in some other adjacent part.

Such observations by means of the microscope indicate that localized deformation is the primary cause of fatigue failure in ductile metals, but it does not necessarily follow that the formation of one slip band under repeated stress will indicate eventual fracture if the loading is continued; one grain may appear to have a greatly reduced elastic limit because of internal strains or peculiarly unfavorable orientation. It is not certain that there is a limiting load below which fatigue failure will never take place.

When the action of metal under repeated stress is considered from the viewpoint of the internal strains and accompanying stresses in the material, a radical difference is seen in the behavior of material under static load and under repeated load. In a general way we may consider any structural or machine part as subjected to static conditions if the load on it is applied gradually and is not repeated more than a few hundred times; the part may be considered as subjected to fatigue if the load on it is applied, say one hundred thousand times or more, and for intermediate conditions of loading the phenomena characteristic of both kinds of loading would be present.

We must look upon steel as filled with a multitude of minute flaws. These flaws are developed in the solidification of the material. In static testing, steel under stress of about half its ultimate strength passes into a semi-plastic condition, in which there is a gradual flow of the material. Under such conditions the small flaws have almost no effect upon the flow or upon the static strength. When steel is loaded to moderate stresses the yielding is almost entirely elastic, but in general a small portion of it is inelastic energy being taken up by the steel itself. If the specimen can be loaded a great number of times without heat loss its temperature will increase. If it is set vibrating in a chamber free from air it will stop vibrating in a short time, due to the absorption of energy. In such cases the stress-strain curve appears to be straight and the curve for the removal of the load may be practically identical with that for

TABLE I—APPROXIMATE SERVICE REQUIRED OF VARIOUS MEMBERS OF STRUCTURES AND MACHINES SUBJECTED TO REPEATED STRESS.

Part of structure or machine.	Approximate number of repetitions of stress in the "lifetime" of the structure or machine.
Railroad bridge, chord members	2,000,000
Elevated-railroad structure, floor beams	40,000,000
Railroad rail, locomotive wheel loads	500,000
Railroad rail, car wheel loads	15,000,000
Airplane-engine crankshaft	18,000,000
Car axles	50,000,000
Automobile-engine crankshaft	120,000,000
Lineshafting in shops	360,000,000
Steam engine, piston rods, connecting rods and crankshafts	1,000,000,000
Steam-turbine shafts, bending stresses	15,000,000,000

the application of load, but still these other effects show loss of energy in the steel itself.

In considering the phenomena of fatigue failure it may be well to call attention to the fact that there is an intermediate type of failure of ductile material in which both plastic action and the development and spread of microscopic flaws are present. Such failures sometimes occur in staybolts, boiler sheets between rivet holes, and other parts occasionally subjected to very severe local distortion.

Localized Stresses Under Static Loading and Under Impact Loading.—When a machine member or structural part is loaded gradually a state of strain and accompanying stress is set up throughout it. In a general way the distribution of stress is similar to that given by the theory of elastic action which serves as a basis of our formula for computing stress and strain. There are, however, many deviations from this distribution due to non-homogeneity of the material and to irregularities in outline such as projecting corners, scratches and tool marks. When load is applied the general behavior of the piece as indicated by careful measurements of stretch, compression, twist, or flexure conforms to that required by the common theory of elastic action, but there are doubtless many localized strains which cannot be detected, even by the use of delicate micrometer measurements.

Under impact loading, which is merely loading applied in a very short space of time, the action is somewhat similar to that under static loading, except that ductile material may offer a higher resistance to very rapid fracture than it does to fracture occurring gradually through a period of several minutes. Impact fracture, moreover, may emphasize somewhat the localized stresses set up at places where the structure of the material is non-homogeneous, or at places where there are sharp notches or deep scratches in the surface of the piece. Under slowly applied load there is opportunity for considerable adjustment and equalization of stress after the yield point is passed; under impact load there is probably less equalization on account of the rapidity of the action, and hence the localized stresses are higher and more effective in causing failure. This explanation of the action under impact is given here because repeated stresses also emphasize the effect of high localized stress, though for an entirely different reason.

Tests and Criteria for Fatigue Strength.—It was formerly the common opinion that the determination of the elastic limit of a material by means of a static test in a testing machine gave a reliable test for the fatigue-resisting qualities of the material, and that the material could withstand an infinite number of repetitions of stress lower than this elastic limit. Tests at various laboratories, however, have quite thoroughly disproved this idea, and have thrown grave doubts on the reliability of the elastic limit as an index of fatigue strength. The term "elastic limit" has always been rather loosely used, and covers several quite different stresses. The value determined for the elastic limit for any material depends on the sensitiveness of instruments used and the accuracy of plotting results, and the elastic limit as determined by such a test in a testing machine is determined by the average behavior of the material over a considerable length, while the process of fatigue failure may be going on over a section so small that it does not appreciably affect the readings of the measuring instruments used. In several laboratories comparative repeated-stress tests of different materials have shown higher fatigue resistance for the material with the lower elastic limit.

It has been proposed by various experimenters to compare the fatigue-resisting qualities of different metals by short-time tests with stresses well beyond the yield point of the material. Such tests are quickly and easily made. Under such stresses, however, the action of the material is partly a plastic flow. Such tests give good promise of determining fatigue strength and toughness under occasional overload for parts such as staybolts, which in their ordinary service are subjected to rather severe distortion, but it is not at all certain that such tests give a reliable index of resistance of machine parts under ordinary working stresses.

It has been proposed by various laboratories to compare the fatigue strengths of various materials by comparing their life under repetitions or reversals of some standard stress, usually less than the elastic limit of the material as determined by a static test. A somewhat similar standard proposed is to determine the stress which will cause failure under a given number of reversals. Standard stresses proposed for steel are 38,000 lb. per square inch (reversal) and 25,000 lb. per square inch (reversal). One million reversals has been proposed as a standard "life." These two types of test approach working conditions more closely than do the short-time, high-stress tests described above. However, they determine only one point on a S-N diagram for a material and do not indicate how fatigue endurance changes with change of stress.

A comparative study of fatigue strengths of various materials can be made from a S-N diagram plotted on logarithmic paper. Up to about 1,000,000 repetitions of stress logarithmic S-N diagrams fall quite closely along straight lines, and from the ordinates and slopes of these lines the behavior of materials under various intensities of stress can be studied. Tests may conveniently be made with stresses at about the yield point of the material, at stresses about 20 per cent lower, and at one or two intermediate stresses.

Various other possible tests have been proposed for determining the fatigue-resisting strength of a material, but no test has been proved to be of sufficient reliability to be accepted as a standard. A number of tests, however, seem worthy of experimental study.

The rate of dying out of vibrations in a "tuning fork" specimen of the material has been suggested as a possible index of fatigue strength. It is assumed that the gradual dying out of vibration is due largely to loss of energy spent in inelastic action in the material, and that such inelastic action is a measure of the fatigue weakness of the material. Test data are lacking to determine the value of this test, but it seems worthy of study.

Tests of magnetic permeability have also been proposed to locate internal flaws in the material and thus indicate its relative fatigue strength. The entire subject of the correlation of the magnetic and the mechanical properties of iron and steel is a promising field of investigation.

The rise of temperature under repeated stress has likewise been proposed as a measure of fatigue resistance. Theoretically, if a specimen is subjected to reversed elastic stress no change in temperature should take place, and it has been proposed to determine the endurance limit for metals at that stress which causes the first noticeable rise in temperature after some thousand or more reversals. A practically difficult in using this test is to secure proper heat insulation for the specimen. This test seems worthy of study, however, especially if employed in an inertia type of testing machine.

The detection of the appearance and growth of "slip lines" in a specimen subjected to repeated stress gives some promise of furnishing a reliable test for fatigue strength. Slip lines appear long before fracture occurs, and if their appearance or the rate of their spread can be shown to be an index of fatigue strength it seems possible that a feasible laboratory test may be devised. The search for slip lines over any considerable area would, however, be very tedious.

Impact tests, usually on notched bars in bending, have been proposed as an index of fatigue strength. The actions under impact failure and under repeated stress are very different, the first giving a sudden break of the entire cross-section of the specimen, and the second a gradually developing fracture. Both failures, however, seem to be affected by localized flaws or irregularities in outline, and though no definite correlation between fatigue strength and strength to resist impact has been established, yet such tests are worthy of study. Repeated-impact tests have also been proposed to determine fatigue strength, but whether such tests have any advantage over short-time tests under non-impact loads is not known.

In all tests to determine fatigue strength it is of the highest importance to secure uniformity of surface finish between the different specimens to be compared. Probably this can best be done by polishing the surface of the specimens where failure is expected.

There is today no short-time test accepted as a standard test for fatigue strength; but the development of such a test, and the establishment of its reliability, would unquestionably be of very great service to testing engineers.

Localized Stress and Its Influence in Producing Fatigue.—The ordinary formulae and methods of analysis used in computing the fiber stress in a machine part or structural member are based on the assumption that the material is homogeneous throughout, and that the cross-section of the member is either constant or that it changes its dimensions so regularly and gradually that there is no appreciable localized fiber stress at sections of rapid change. For structures and machines of ductile material subjected to not more than a few hundred loadings, such assumptions are reliable, because localized stresses do not appreciably affect the general deformation of a member, nor do they under ordinary working conditions cause trouble before the member has been subjected to some thousand or more repetitions of load. For nearly all parts, however, high localized stresses are present. Internal flaws may cause such localized stresses. This is shown by mathematical analysis of stress in plates with holes in them and by direct experiment on such plates. External irregularities of outline may cause localized stress. Under bending or twisting a member with a sharp re-entrant angle in its outline theoretically develops an infinite stress at the root of the angle, and actually both mathematical analysis and direct experiment show that very high localized stress may be caused by sharp grooves or scratches on the surface of a machine part or structural member.

It has been stated above that for parts subjected to a few loadings localized stresses are not of great significance. The case is quite different, however, for parts subjected to thousands of loadings. High localized stress may cause a crack to start, either directly or by "cold-working" the material where the localized stress exists until the material becomes brittle. This crack forms an extension of the discontinuity of the material which caused it, and under repeated stress tends to spread still more rapidly. This tendency is illustrated by the action of a piece of plate glass in which a crack has started. In most cases under any repetition of load the crack spreads, and will cause final fracture of the glass. A fatigue failure under repeated stress is a progressive failure. This spreading of cracks to cause failure explains why under fatigue even ductile materials snap short off. Failure does not involve plastic flow of considerable masses of metal, but only of microscopic masses near the crack and final fracture comes suddenly just as if the members were cut half off by means of a saw cut and then bent. The importance of avoiding localized high stress in members subjected to repeated stress can hardly be overemphasized. Homogeneity of internal structure, smoothness of external surface and avoidance of sudden changes of cross-section may be more important in the construction of machine parts subjected to repeated stress than is high static strength of material.

Shoulders of crankshafts and of axles, keyways in shafts, screw threads, and rivet holes are examples of locations where high localized stress is liable to occur.

Formulæ for Designing Parts Subjected to Repeated Stress.—All formulæ which have been proposed for designing parts subjected to repeated stress depend upon extrapolation from test results and should therefore be regarded as tentative. Their use is justified only on the ground of necessity. Parts must be designed to resist repeated stress, and even formulæ derived from a confessedly inadequate experimental basis seem better than mere guesswork. Two types of formula have been used.

In many discussions of data of repeated-stress tests, it is assumed that there exists some definite "endurance limit," that is, some stress, greater than zero, which can be repeated an infinite number of times without causing failure of the material. If such a limit exists it is certainly lower than the elastic limit of the material as determined by static tests, for actual failures of materials have occurred under repeated nominal stresses as low as one-quarter of the elastic limit as determined by a static test. Examination of test data indicates that the endurance limit is an assumption rather than a proved fact. It is usually determined by plotting a diagram with stresses as ordinates and number of repetitions producing failure as abscissæ and estimating the stress for which the diagram seems to become horizontal. Various other methods have been proposed, but all involve this assumption.

In 1910 a paper presented before the American Society for Testing Materials pointed out that an examination of the results of numerous series of repeated-stress tests indicates that for nearly all the range covered the law of resistance to repeated stress may be expressed by the equation:

$$S = KN^{-m} \quad \ldots\ldots\ldots\ldots [1]$$

in which S is the maximum unit stress developed in the test piece, N the number of repetitions of stress necessary to cause failure, and K and m are constants depending on the material and somewhat on the manner of making the test. This is known as the "exponential equation for repeated stress."

Another form of expression for the above equation and frequently more convenient, is:

$$\log S = \log K - m \log N \quad \ldots\ldots [2]$$

If the logarithms of S and N are plotted, or if the values of S and N are plotted on logarithmic cross-section paper Equation [2] is represented by a straight line. Fig. 1 shows the S-N diagram given by a series of repeated-stress tests. In Fig. 7a ordinary co-ordinates are used, but in Fig. 7b the co-ordinates are logarithmic. For large values of N the exponential equation gives in many cases values of S smaller than the observed values; in other words, the exponential formula seems to err on the side of safety.

It will be noted that the use of the exponential formula involves the assumption that any stress if repeated often enough will eventually produce failure of the material. Thus while both the endurance limit and the exponential formula are based on extra-polation from known data, the exponential formula seems to be an assumption on the safe side. The working stresses as developed by the two methods do not differ greatly except for members subject to more than 10,000,000 repetitions of stress. Above that number the exponential formula requires lower working stress, but even then the stresses given by the exponential formula are not impracticably low.

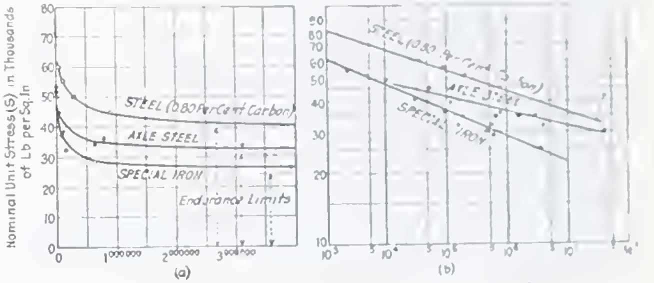

Fig. 1—Stress-Strain Diagram.

While nothing but tentative formulæ can be proposed now, some features which a satisfactory formula for fatigue strength should include may be noted. It is probable that such a formula for any material will not depend on ordinary static qualities of the material such as elastic limit or tensile strength. It may depend on some form of elastic limit determined after the material has been put in a "cycle" or "normalized" state by a number of reversals of stress. Such a formula will quite probably contain factors dependent on the surface finish of the part and upon the uniformity and regularity of its crystalline structure. It will contain a factor dependent on the range of stress during a cycle. Such a formula may contain a factor dependent on the probable number of repetitions of stress which the part may be expected to withstand during a normal period of service or the result may be an "endurance limit"—a stress which the part is capable of withstanding so many times that even for modern high-speed machinery the number of repetitions may be regarded as infinite.

Preventing Discarding of Goggles in Hot Weather.—A novel and effective method of counteracting the hot weather inclination on the part of workmen to discard goggles has come to the attention of the National Safety Council in the plant of one of its members, the Aluminum Castings Co. of Cleveland, O. This company found that on hot days many workmen were tempted to lay aside their goggles when the lens became steamy or clouded from perspiration. To eliminate this dangerous practice the firm gave the men neat wiping cloths, about 4x6 in. each, which may conveniently be carried in the goggle case. Each cloth carried the printed message "Use this cloth to keep your goggles clean" and a safety slogan of which the following are examples: "Goggles save your eyes." "Goggles are to protect your eyes—not your cap." "You can't see with a glass eye—wear your goggles today." "Take care of your eyes—your goggles will do it." "What would you take for your eyes? Think it over."

A Recording Extensometer and the Measured Stresses in A Concrete Hull*

The dead weight of the hull of a reinforced concrete ship is a limiting factor in the carrying capacity and the economic operation of the ship. No studies have ever been made of the forces which a ship must resist or of the stresses developed under the actual conditions of service. In order therefore to determine the possibility of reducing the weight to the absolute limit consistent with safety, the Concrete Ship Section of the Emergency Fleet Corporation determined upon a comprehensive study of this problem, viz., the stresses in a vessel during launching and under actual conditions of service.

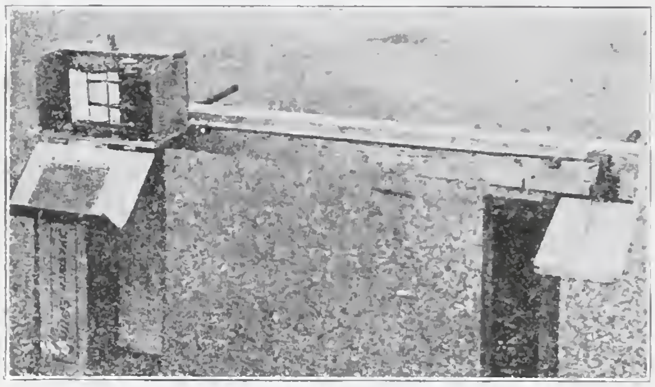

Fig. 1—Strainagraph Set Up as It Was on Concrete Ship.

Recording pressure gages to determine the depth of flotation and buoyancy were obtained in the open market and could be modified for use in the hull without much difficulty.

Recording strain gages or extensometers called strainagraphs, however, were not on the market, as a whole, but the recording mechanism as made for the "pressuregraphs" was utilized. Speed was the essential, and a Boston firm delivered eight machines fifteen days after receipt of order.

The strainagraph is an extensometer equipped with a time recording device. The recording end is fastened at one point of, say, a deck beam; the end of rod extending from this is fastened to another point of the beam. A strip of paper driven by a spring and subsequently by a motor passed under a recording pen whose motion is induced by the extension on contraction of the concrete between the two points of the support The multiplication of the strain as recorded is about 140, but must be determined for each instrument in place, and is easily accomplished by the use of an ordinary Ames extensometer.

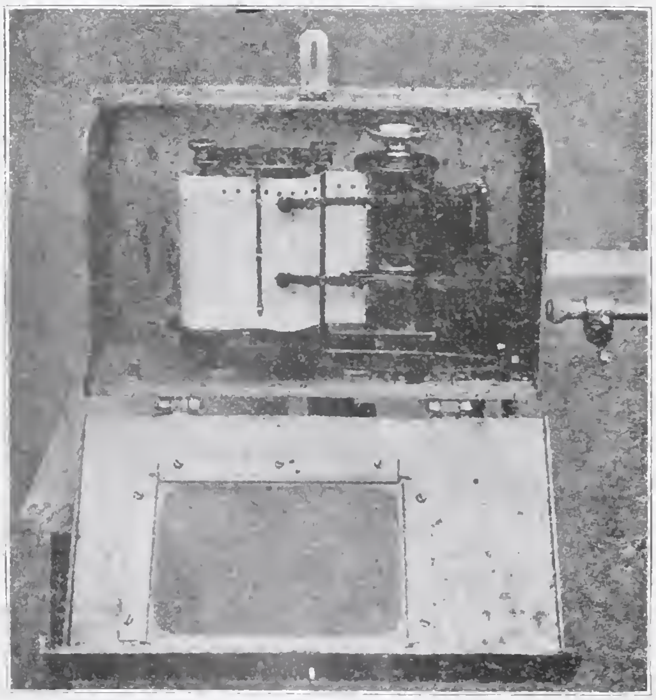

Fig. 2—Recording Gage Box of Strainagraph.

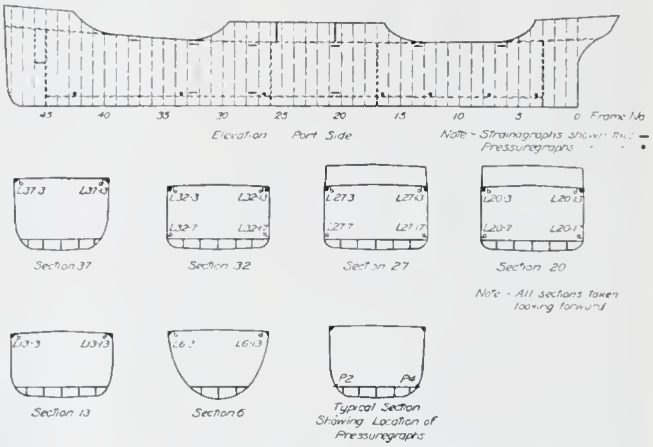

Fig. 3—Location of Instruments on the "Atlantus."

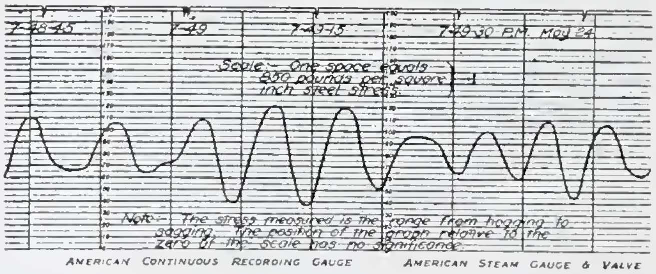

Fig. 4—Specimen Strainagraph Record.

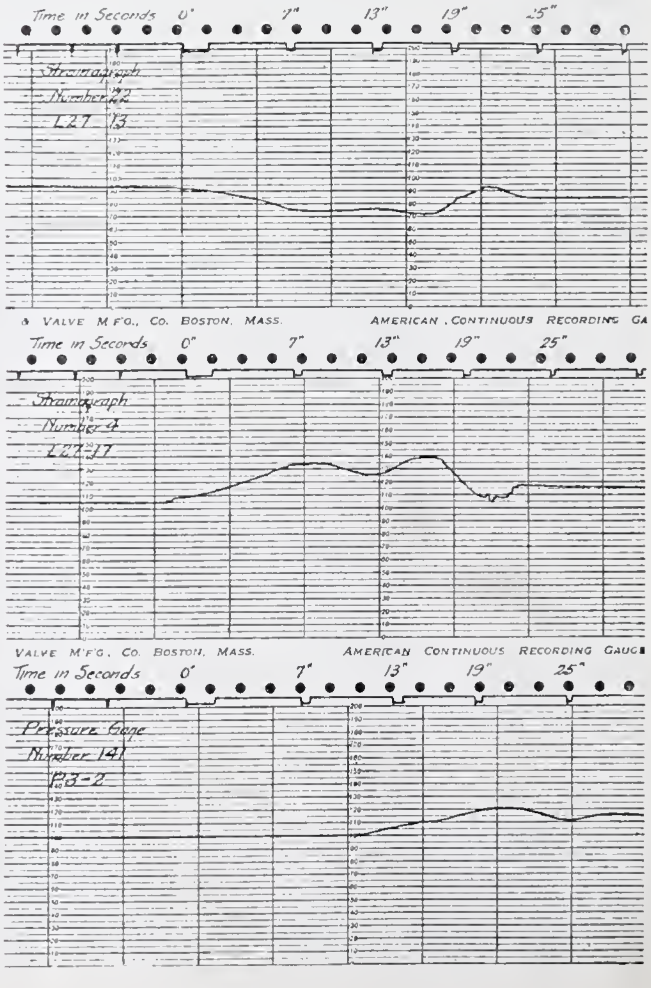

Fig. 5—Specimen Records from Strainagraph.

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*From a paper by Franklin R. McMillan, Research Engineer, Concrete Ship Section, Emergency Fleet Corporation, Philadelphia, presented at the annual meeting of the American Concrete Institute, June, 1919.

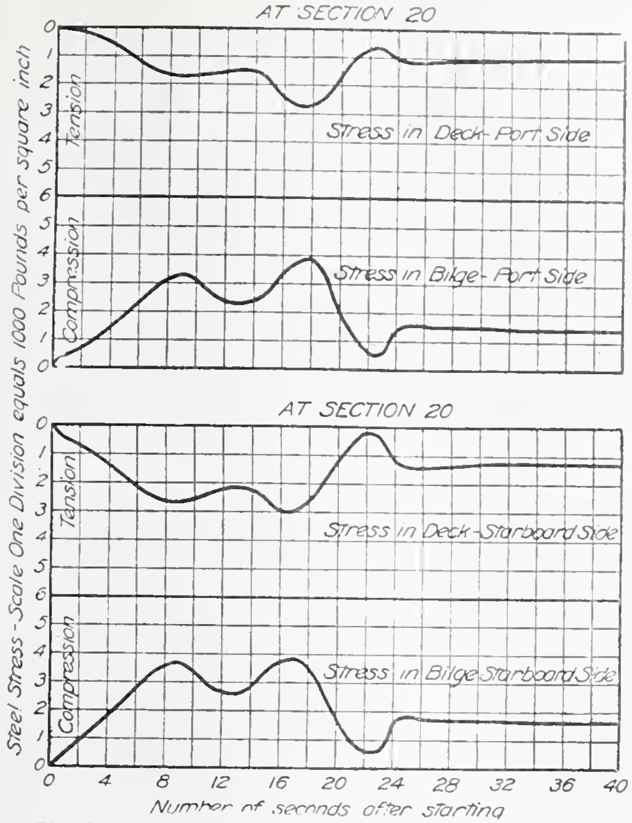


Fig. 6—Longitudinal Stresses on "Atlantus" Launching.

In addition to recording a continuous line giving the changes of length between the predetermined points, another pen operated by a magnet is capable of placing its mark on the paper strip. In operation, say during the launching of a vessel, pressuregraphs are put on the lower part of the hull communicating with the outside, strainagraphs are placed near the upper and lower side of hull for longitudinal launching, as indicated in Fig. 3. The driving mechanism motors are all interconnected, so that by means of resistances their speed can be regulated. The "magnetic" pens are on another circuit in connection with a clock, giving two impulses at each minute and a single one at 10-second intervals. A telegraph key gives a further chance to identify the minutes. Simultaneous records are thus obtained of pressures and strains in predetermined places of the hull. Using the ordinary modulus of elasticity of steel or concrete, strains are easily changed into stresses.

Remarkably smooth curves were obtained. Figs. [illegible] and [illegible] are specimens of records. Fig. 6 shows the [illegible] stresses.

An examination of this curve shows that hogging stresses (that is, tension in the deck) began to develop as soon as the hull started to move and these increased until about the 9th second. Following this will be seen a partial return to a condition of no stress and then a further increase to about the 18th second. From the 18th to the 22d second there was a sharp decrease in the stresses to very nearly zero at all points and a quick return to the condition in which it remained in quiet water.

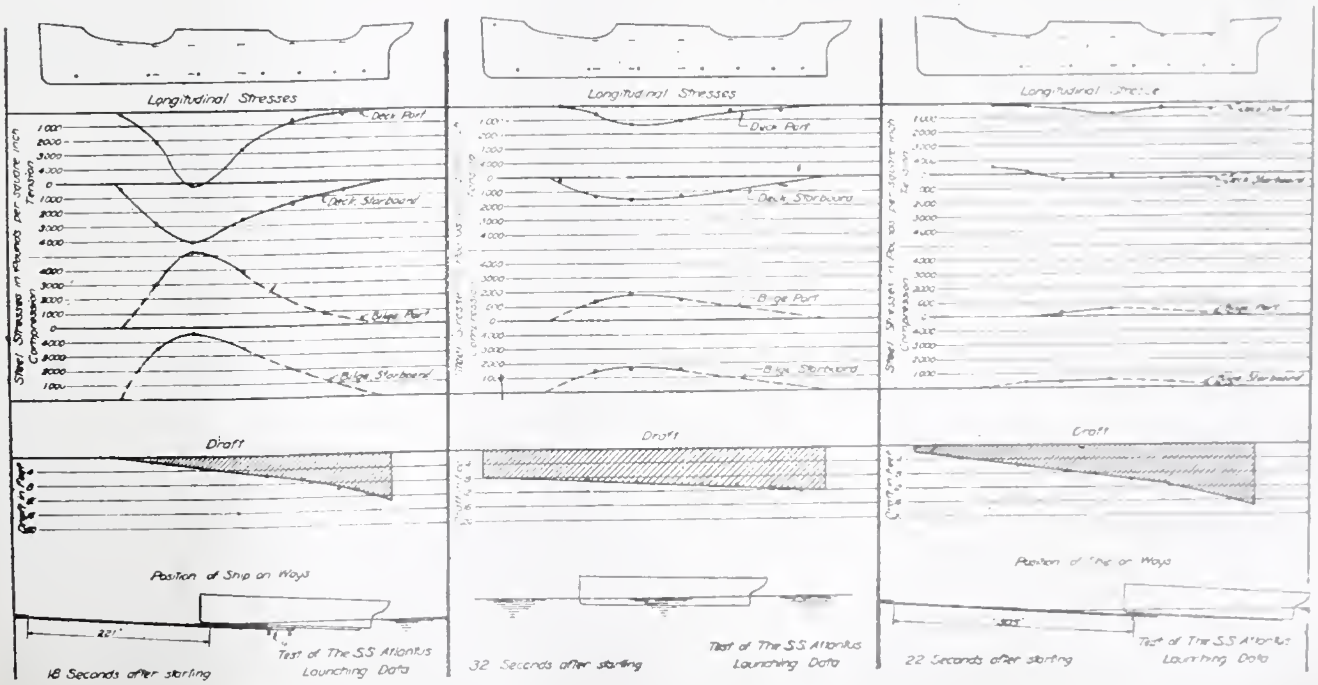
The stress during the first 12 or 17 seconds was due to a slight vertex in the ways, due to irregularities in construction, over which the hull had to pass. From the 16th second the stress was due to the hogging of the ship over the end of the ways. This reduced to almost no stress from the 18th to the 22d second as the buoyancy at the stern increased. From the 25th second to the end of the record the hogging stresses are due to the normal hogging moment in the hull.

The variation in stress along the ship at the 18th second is shown in Fig. 7. The data for these curves were obtained from the curves similar to Fig. 6. This figure shows also the position of the ship on the ways and the observed drafts for that instant. Similar curves for the 22d and 32d seconds are shown in Figs. 8 and 9. These show respectively the conditions at the time of lowest stress and under the final hogging moments.

The most interesting feature of this test is the comparison of the resisting moment as determined from the strainagraph records with the applied moments as calculated from the observed drafts. This comparison is shown in Fig. 10 for the three sections where measurements were made at both top and bottom. The calculated moments were obtained by the usual calculations based on known weights and buoyancies.

In calculating the resisting moments from the stainagraph data the same assumptions were made as were used in the preparation of the design of the ship. These include those usual in the common theory of flexure and the further assumption that the bulwarks and bridge deck did not add to the resisting moment. It should be noted here that the bridge deck and bulwarks were cast separately from the hull and expansion joints were provided about 25 ft. apart. All the indications from the data point to the reasonableness of these assumptions and until further data is obtained from the behavior of this ship at sea it seems fair to accept them.

These calculations for resisting moment were made for a beam of homogeneous section, giving to the steel area a weight equal to the ratio of its modulus of elasticity to that



Figs. 7, 8 and 9—Launching Data at Different Periods of Launching of "Atlantus."

of the concrete. Tests of 31 cylinder specimens from various parts of the ship show an average value of 2,560,000 for the modulus of the concrete. A ratio of 12, therefore, was used on these calculations both for weighting the steel area and in reducing deformations in the concrete to equivalent stresses. The assumption as to the homogeneity of the section is considered fair, as the maximum tension did not exceed 500 lb. per square inch, and there was no evidence of tension cracks after the launching.

Referring now to Fig. 10: The real significance of the agreement between the two sets of curves will be appreciated. These curves represent the moments in the ship during the critical period of launching as determined by two independent sets of measurements of a widely different character. One set of curves gives the calculated applied moments based on water pressure observations, and the other set of curves gives the measured internal moment of resistance based on measured deformations in the hull.

In regard to section 32, it may be said that the curve of applied moments at the forward end of the hull cannot be determined as accurately as elsewhere because of the uncertainty in the distribution of the reaction from the ways.

In the light of these considerations it may be stated that the results are very satisfactory and show a high degree of reliability in the instruments. They also give a fair indication of what may be expected in future tests where it will be possible to eliminate some of the uncertainties encountered here.

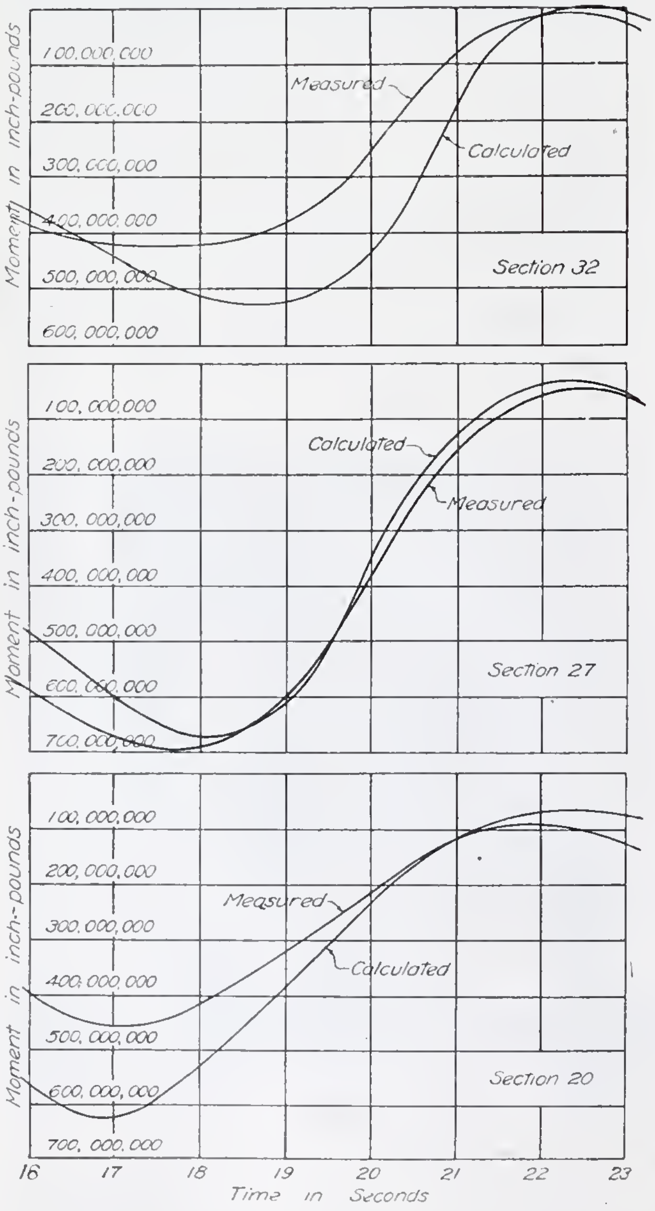


Fig. 10—Comparison of Measure and Calculated Stresses on "Atlantus" During Launching.

Flat Panels and No Surface Checks by Maximum-Humidity Method

If panels are over-dried their tendency toward warping and twisting is greatly increased. The lower the moisture content the more the warp. The short time required for drying panels varying from a few hours for thin panels to a few days for thick ones, makes it impracticable to make actual determinations of moisture content to decide when the material has reached the desired degree of dryness.

An automatic method of insuring the proper moisture content in dried panels is proposed by the Forest Products Laboratory. This is what may be called the "maximum humidity method," in which the relative humidity of the air in the kiln or drying room is regulated so as to remain at the highest level which will permit the wood to dry to the desired degree (and no further) in a reasonable length of time. By this method checking of face veneer is also prevented.

The maximum-humidity method lends itself to the most convenient and economical handling of the panel-drying operation. As there is little danger of over drying, the stock may be left in the drying chamber for any reasonable length of time beyond the minimum required. Thus, thin panels and thick panels may be taken from the press and placed in the kiln at the same time, and removed at the same time, even though the thin panels dried much quicker.

For panels made up of normally dry veneer, a kiln temperature of 120° F. throughout the drying period is a good schedule to follow. If with this temperature the humidity is maintained at 46 per cent, the panels will come uniformly to a final moisture content of about 8 per cent within a reasonable drying period. If the same temperature is used and the humidity is maintained at 57 per cent, the panels will not dry appreciably below 10 per cent.

Moisture Absorption Through Varnish Same for Different Species of Wood

In experiments made by the Forest Products Laboratory, it was found that varnishes do not entirely prevent the transmission of moisture into wood but merely retard it, and that apparently there is no difference in moisture absorption through the coating due to the species of wood used.

The panels used in the experiments were of yellow birch, basswood, red gum, African mahogany, white ash, white pine, Sitka spruce, southern yellow pine, bald cypress, incense cedar, white oak, western yellow pine, Port Orford cedar and sugar pine.

Three coats of high-grade spar varnish were applied to 4 panels of each species. Two panels of each species were brush-coated and 2 were dipped by a special dipping machine designed to secure an even coating. The panels were allowed to dry 72 hours between coats and 10 days after the final coat before they were given the moisture-resistance test.

The moisture-resistance test consisted in exposing the panels for 17 days to a humidity of 95-100 per cent, or in an atmosphere practically saturated with moisture.

At the end of this test, it was found that all the brush-coated panels had absorbed beween 5 and 6.5 grams of moisture per square foot of surface, and the dipped panels between 4 and 5 grams. Such variations in amount of absorption as appeared could easily have been due to inequalities in the application of the varnish. It was quite noticeable that the dipping process produced a more moisture-resistant coating than brushing.

Co-ordination of Government Agencies for Map Making.—President Wilson has advised Engineering Council that he was arranging a conference to consider the advisability of co-ordinating the work of the several agencies of the Government which are charged with map making. In calling the President's attention to the need of such action Engineering Council pointed out that the official map work of the United States is now being prosecuted by 12 separate and distinct Federal agencies, the majority of which are making maps for special purposes, which maps are of little value for any other purpose, and we are confident that if the aggregate efforts of Government were co-ordinated on the making of a base map of suitable accuracy and scale, it would serve for all Governmental as well as private purposes and could be adapted without great expense to any special or unusual purpose.

Common Errors in Municipal Finance

Errors in municipal finance are usually the result of carelessness, ignorance or politics, and while the A, B, C's of municipal finance are common knowledge and very simple, the above abuses are bound to occur unless diligence is applied at all times. In a recent issue of Pacific Municipalities Mr. A. R. Hebenstreit, City Manager of Albuquerque, N. Mex., points out these errors usually manifest themselves in either of the following: First, Crude Financial Legislation; second, Lack of Modern Accounting Methods, including a real budget system; third, Improper Handling of Bond Issues and Certificates of Indebtedness; fourth, Failure to Properly Regulate Public Utilities and Public Utility Franchises; fifth, Inability to take Advantage of Competitive Purchasing. The following is quoted from Mr. Hebenstreit's article:

Crude Financial Legislation.—This is often brought about by an effort on the part of a well meaning legislature to arrest or curb the actions of public officials who have previously, unknowingly or willfully abused good business practice. Oftentimes financial legislation is effected by the influence of large corporations, who oppose certain classes of legislation for selfish reasons and launch other legislation of less merit for the same reasons. Oftentimes legislators will legislate to effect a particular locality which has come to its attention, neglecting to ascertain the full import of that legislation to other localities. I believe it is the duty of municipalities to keep their legislature informed of local conditions so as to have their legislators represent them intelligently. This can be accomplished best by an organization of a state league of municipalities in each state in the Union and these states in turn organize a national league of municipalities for the purpose of representing municipalities in national legislation.

Lack of Modern Accounting Methods.—Lack of proper accounting methods in a municipality or in any business is the cause of bankruptcy or wastefulness in a large percentage of cases. Detailed knowledge of every financial transaction, no matter how trivial, will oftentimes avoid unnecessary expenditures and with the proper utilization of the budget system will cause the city officials to anticipate the needs of the city and make necessary provisions for same. The budget system must be utilized properly, otherwise it is more of a hindrance than an advantage. For instance, in the state of New Mexico, the law requires that the expenditures for the ensuing year shall be budgeted for approval. However, when it comes to budgeting the income of a municipality, the budget system is entirely discarded by an arbitrary rule which says that no municipality will levy beyond a certain limit. In other words, we have a budget for expenditures but no budget for revenue. The budget system in the state of New Mexico is, therefore, useless. It is hoped through the efforts of the New Mexico League of Municipalities to submit to the next legislature a workable budget system for municipalities.

Improper Handling of Bond Issues.—Bond issues are opposed by the conservative element, although recommended by the more progressive element. It is a well known fact that bond issues are legitimate and equitable when made to pay the cost of a permanent improvement; and when the sinking funds necessary to retire the bond issue are distributed over a period of time so that all of the future generations deriving benefits from the permanent improvement will assist equally in paying for that improvement. The usual method adopted by municipalities, and which in my opinion is one of the greatest mistakes that can be made, is neglecting to establish sinking funds for the retirement of the bonds immediately after the public improvement is available for use to the people; also failure to extend the payments over a period of time approximately three-fourths of the recognized life of the permanent improvement. Common practice is to postpone the first sinking fund requirements for a period of 10 to 15 years so as to relieve the present generation even though that generation will have the use of the permanent improvement. Mistakes are also made in extending the period of the bond issue, far beyond the life of the improvement. To illustrate this last point, I have knowledge of one bond issue which provided for payments over a period of 20 to [illegible] years, although the life of the structure, when originally built was not more than 15 years and should not have been bonded for a period of more than 15 years. Another mistake often made in State laws relative to bond issues, is that they require a bond election to be held at a general election. This is absolutely wrong for the reason that other political issues oftentimes cloud the real issues relative to the bond election and many times a meritorious bond issue is defeated because of the ability of one political faction to defeat another.

Certificates of indebtedness are only of value where it is impossible to have a bond issue at times other than at a general election or where the improvement contemplated is a district matter rather than that of the entire city. The issuance of certificates of indebtedness for a community improvement in my opinion is poor practice unless made necessary by the inability of the governing body to call a bond issue election. The governing body must have the power to issue certificates of indebtedness in the operation of public utilities because if a major improvement is contemplated there are very few businesses capable of financing such an improvement out of one year's earnings. It is then necessary that such improvements be spread over a period of years by issuance of certificates or until such time as a bond issue can be floated.

Failure to Properly Regulate Franchises.—Public utilities and public utility franchises should be at all times under full supervision of the governing body of the municipality in order that their operation and construction may be regulated and the granting of franchises should be made a matter of income to the city in return for the benefits derived by the public utility from the city. By this I do not mean that public utilities should be militated against by any governing body of any municipality but that the governing body should have the power to regulate that public utility so as to guarantee a fair earning power and to protect the citizens against excessive rates.

Competitive Buying.—It is unnecessary to go into detail with reference to competitive buying. Everyone knows the advantage of competition in securing a maximum amount of service for the money expended. However there are times when public advertising for bids is not the best method. Oftentimes business concerns will make better prices when they know that their prices are not to be made public. Again when public advertising is utilized there is oftentimes a tendency to accept the lowest bid regardless of quality of goods or integrity of the bidder. If these two defects can be avoided, competitive buying will save many dollars to municipalities.

The above points are touched upon with the idea of merely calling them to the attention of persons who may minimize their importance and further development of these views will reveal to the reader countless other abuses which are oftentimes unintentional.

Engineers on Regulatory Commissions

Regulatory commissions would undoubtedly be very weak an inefficient institutions if they were without competent engineering advice. Of course they secure the services of engineers, but usually as members of the employed staff. The Engineering Council has advanced in a new quarter the plea that engineers should be appointed members of the commission, where they will have authority as well as to advise. J. Park Channing, president of the council has written to President Wilson asking that when a vacancy on the Interstate Commerce Commission occurs consideration be given to the appointment of an engineer. His purpose is expressed as "not to further the interest of any individual or group, but solely to serve the nation by strengthening one of its most important regulatory bodies." If the appeal meets with the approval of President Wilson it will lead to an excellent opportunity for some engineer to prove the usefulness of the profession in this vital branch of public service. Public affairs are very closely geared to private affairs in these times and the best engineering thought and ability of the country is essential to stable progress under the conditions following the end of war. The Engineering Council speaks for a large circle and its plea is founded, not on selfishness, but on appreciation of the importance of balanced commissions to weigh the problems which touch all ranks.—Editorial in Electrical World.

The Engineer and Public Affairs*

By HOWARD C. PARMELEE.

One of the fundamentals in advertising is that if you say a thing often enough, you will not only convince all who hear you, but ultimately you will believe it yourself. It is on some such principle as this that I propose to discuss a subject that has been the theme for many presidential addresses during the year, hoping always that if the world is told often enough of the need for engineers in civil and political life, the people will be convinced, and engineers themselves will finally believe it.

Human experience has shown clearly that there are compensations for many incidents which in themselves seem wholly disastrous and without recompense; and so it is that out of the admitted cataclysm of war which has engulfed the world has come a definite demand for engineers, a keener appreciation of their service, and a belated recognition of their need in business and government. I have reason to believe that this recognition is a world-wide as well as a voluntary tribute, and that it offers the engineer an advantage which he must grasp if he would retain it. Had he the tradition or the training of the lawyer, he would not only accept this position of eminence from those who are willing to accord it, but would exercise his gift of speech to persuade the remainder that no mistake would be made in committing to his care the conduct of the world's affairs. But our engineer has been so unused to the limelight that he is likely to shrink from the public gaze and retire modestly to his laboratory or works. Being the lineal descendant of the artisan, and having long been accepted in the public mind as a glorified mechanic, he will be apt to retire all to readily to the background. He needs, as never before, the support and encouragement of the professional society to give him that solidarity and community of interest which will enable him to stamp his influence on the affairs of the world.

I think we may justly claim to have established a profession of engineering, although some may contend that we still have merely a "procession of engineers." By definition, a profession is that calling or occupation which one professes to understand, a vocation in which a professed knowledge of some department of science or learning is used by its practical application to the affairs of others. Formerly, theology, law and medicine were specifically known as "the professions," but I think we may fairly claim to have established engineering on a more solid and scientific basis than any of them. Theology has been almost wholly speculative, the law technical, and medicine empirical. Each has been irrational, and all have gained prestige by claiming it.

On the score of service to humanity, also, I think that engineering may fairly claim professional standing. The achievements of engineers in all parts of the globe are accepted evidence of their ability, but tradition causes us to halt at this recognition, as though the only field in which an engineer could accomplish anything was in the design and construction of some great work. Such things are well enough in themselves, but in the meantime the affairs of business and government are left to men of limited training and narrow vision, and those things which are fundamental in our national life are suffering from the lack of vital direction, which engineers could give.

We have sometimes heard it said of an individual that "he may be a good engineer, but he is no business man." I resent the implied difference. An engineer is a manager, one who carries a project to conclusion in an efficient manner. I might consent to such a statement as "he is a good mathematician, but no business man," or "he is a good surveyor, or assayer, but no business man," but I must contend that if he is a good engineer, he will be a business man. The war has brought out few more striking incidents of management than the direction of the commission for relief in Belgium by Herbert C. Hoover, an engineer of technical achievement in his profession. This commission handled until near the close of 1916, $227,000,000 worth of supplies, keeping alive a population of 9,000,000 and operating with an overhead expense of but three-quarters of 1 per cent of the gross cost. Such is engineering efficiency in business, organized in an emergency, and administered under constant stress. What might such ability accomplish applied under the normal conditions of business, with ample time for planning and execution?

The engineer is entitled to recognition not only as a producer but as a director of policy. Hitherto he has accepted the responsibilities of operation and production, while the control of the enterprise was in the hands of a banker or merchant. Under these conditions, the work of the engineer might be ever so efficient, and yet the enterprise might fail through ignorant management in the executive or selling department. Complete control on the part of the engineer might avoid such a catastrophe and relieve himself, as well as his associates, of inevitable embarrassment. I think that engineers are coming to demand this form of control, being willing to accept responsibility if they are also given authority. Any form of dual control, with the responsibility still resting on the engineer, is intolerable.

The modern engineer can bring to bear on business all of the general essentials to success. Organization is his forte and management his specialty. With him the handling of men and supplies is a matter of scientific procedure and the keeping of accounts and unit costs a prime necessity. Plainly the ability of such a man should not be confined wholly to the details of operation or production, but should be requisitioned on the board of directors or the executive committee.

Perhaps it is more in the realm of government of civic and political activity that the engineer is yet to receive his highest recognition. Certainly it is in this field that he must strive most earnestly for a hearing and for a chance to apply his methods. The strongest traditions are gainst him, and he is handicapped by a lack of familiarity or intimate relation with political organizations. There is no question, however, that his ability, viewpoint, and methods are sadly needed. Accustomed to considering propositions on their merit, and having an abhorrence of waste and inefficiency, he would be less likely to yield to political expediency in matters of great consequence. I doubt if "pork barrels" would appeal to engineers having ethical standards as high as our statesmen would probably assume for themselves.

There is probably a growing demand for fewer lawyers and more engineers in our civic and political life. There has never been a time in our national history when technical and engineering advice was more needed in matters affecting our industrial growth and welfare. The intricacies of the dyestuff tariff, for example, could not be reckoned with intelligently by lawyers and merchants, nor can the revision of the mining law be sanely undertaken by men who merely own stock in mining companies.

Popular impression prevails that governmental departments are not on an efficient basis, and engineers can render a service to the country by expressing that opinion in a manner so forceful as to show Congress the light.

Our legislatures and city councils are no less in need of engineering advice than is Congress, while state and municipal affairs generally are subject to abuse and need correction. Town planning and management are engineering problems of first rank, wholly beyond the scope of politics and above the grasp of politicians. Numerous departments of government depend upon technical direction for their successful operation and for the economic handling of funds. In such things engineers should not only take an active part, but should advise those in authority.

Some attention also may be profitably turned to the daily press of this country. There is no more potent force in spreading information or creating public opinion. In technical and engineering matters, however, it is woefully ignorant and in need of sound advice. If we could encourage the editors of our dailies to consult with engineers and scientists on pertinent topics before publishing their dispatches or writing their editorials we would prevent the dissemination of a lot of things that are not so and avoid the ridicule which inevitably is heaped upon newspaper science.

I admit there are other things wrong with our newspapers, which engineers cannot correct, and I am not recommending that engineers become editors of our dailies, for I doubt if we would have much in the way of newspapers under such direction; but I do think it is possible to encourage a closer co-operation between newspapers and engineering of scientific societies, so that the public would get more exact information on technical matters.

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*From the presidential address at the annual meeting of the Colorado Scientific Society, Dec. 6, 1916. In order to comply with the government's request to conserve paper, the address was not published by the Society until June, 1919.

Comparative Strength of Old and New Douglas Fir Timbers

Tests of large size Douglas fir timbers that have had 36 years' service in the frame of the former city hall of Oakland, Cal., have been made in the testing laboratories of the civil engineering department of the University of California. The results of these tests and comparisons with tests of fresh cut Douglas fir are given by Mr. Arthur C. Alvarez in Bulletin 2, Volume 2, of the engineering publications of the University. Mr. Alvarez's conclusions include the following:

For compression parallel to the grain, comparing results of 2x2-in. specimens free of defects, all reduced to 12 per cent moisture, the elastic limit of the long-used timber is about 85 per cent of that of the freshly-cut material, but the maximum crushing strength of the former is 3½ per cent greater than that of the latter.

The modulus of elasticity of long-used timber in one case is twice as great as that of freshly-cut Douglas fir. In the other case, when the reduction to 12 per cent moisture is made, the moduli of elasticity are equal. The ultimate strength of the 2x2-in specimens show that the long-used timber surpasses the freshly-cut timber by about 360 lb. per square inch, or 9 per cent, at the elastic limit, and by 1,640 lb. per square inch, or 33 per cent, at the maximum crushing load. A similar comparison for the largest sizes shows that the former are stronger by 300 lb. per square inch, or 9 per cent, at elastic limit, and by 940 lb. per square inch, or 22 per cent, at the maximum crushing load. This comparison shows that the static compressive strength parallel to the grain of air-seasoned timber may increase in time during use under favorable conditions.

The results for longitudinal shear on 2x3-in. or 1½x3-in. areas show that the long-used timber is stronger than the freshly-cut material by 698 lb. per square inch, or 85 per cent. This shows how greatly the longitudinal shearing resistance of small sections of Douglas fir wood fibre may increase with age, provided defects such as checks, shakes and knots are absent.

The results for compression perpendicular to the grain for the largest size of long-used timber exceeded that for corresponding sizes of air-dry specimens by 243 lb. per square inch, or about 38 per cent. This may be due to difference in moisture content.

The results of the static bending tests on large beams indicate that the static strength in longitudinal shear due to increased seasoning kept pace with the deterioration due to increased checking. Under favorable conditions, Douglas fir of large structural size with ordinary defects does not deteriorate in use when exposed to bending under static loading, but maintains the strength it had in the beginning. Age does not seem to intensify the weakness due to defects.

Impact tests in beams of clear material indicate that Douglas fir after long use is only about 86 per cent as strong at the elastic limit as freshly-cut material of the same moisture content, but is 95 per cent as strong as freshly-cut Douglas fir containing 20 per cent of moisture, a condition which approximates "air-seasoned" on the market. Long use renders Douglas fir fibre slightly less resistant to loading suddenly applied.

Working stresses for longitudinal shear should be based on the results of tests of specimens similar in character to the details of the timber structure to be designed.

Mechanics Not Engineers.—The following letter on the necessity of eliminating whenever possible the use of the word "engineer" as applied to craftsmen who are not engineers can be used to good advantage in organizations where there now exists confusion in the use of this word, states The Monad. This letter was recently sent to resident engineers from the office of F. M. Sawyer, Assistant Engineer in the construction department of the Pennsylvania R. R.:

"In preparing monthly estimates showing labor items, please use the word 'engineman' instead of 'engineer' in connection with steam shovel, dinkey, etc. A mechanic is not an engineer, although an engineer may be a mechanic.

"All the national engineering societies are working toward a proper recognition of the engineer by the general public, but if we engineers continue to class mechanics, no matter how skilled, with ourselves, we cannot expect the uninitiated to differentiate."

The Organization of a Laboratory for Industrial Research*

By A. D. LITTLE AND H. E. HOWE

Previously to the war there were about [illegible] industrial research laboratories in the United States, including those maintained by manufacturers for their own benefit and commercial laboratories prepared to render similar service. At the present time there are no figures available regarding the number of new laboratories established as a result of the war, but there is no doubt but that the war created a deeper interest in industrial research, and the application of science to manufacturing processes. It is also evident that those laboratories which existed before the war are displaying a greater interest in fundamental research, and in rehabilitating their organizations are paying far more attention to the research phases of their problems than they have been willing to do heretofore.

In discussing the industrial laboratory we may choose between the one organized for the purpose of exploring some small corner of the broad field symbolic of our ignorance and an establishment concerned with the greatest variety of problems. A laboratory of the latter type should consist of a collection of special laboratories carefully articulated to produce results most efficiently, and the work common to all of them should be organized separately in a large general laboratory. Fortunately for our country there are several such laboratories doing splendid work and notwithstanding the care exercised to avoid undue specialization, nearly all of them contain departments which dominate due either to stronger men or the greater appeal which these departments make to the company, or perhaps to a seemingly greater importance of their class of problems at the moment. The great majority of these laboratories are maintained in the plants of industry at an annual expense running up to two millions in at least one case, and with many spending hundreds of thousands each year.

Another plan which should be mentioned involves the training of men as a primary consideration, and the Mellon Institute, at Pittsburgh, affords a conspicuously successful example of what may be done in educational institutions in solving the problems of industry, while at the same time men are trained in research.

The Aims of a Research Organization. Broadly stated, the aims of a research organization should be:

(a) To find, develop and train men.

(b) To create such a background in the public mind as shall insure support for research and the industrial utilization of research results.

(c) To secure co-operation between different branches of science, as, for example, between chemists and mathematicians.

(d) To avoid repetition and duplication of effort, first by rendering present knowledge readily available to research workers, second by applying clearing-house methods to research projects.

(e) To stimulate research by emphasizing the importance of specific problems, making special grants, rendering material and facilities as generally available as possible.

(f) To furnish a general staff for research which shall work out the plan of attack for major problems, assign the several lines to competent workers and co-ordinate and focus the whole.

(g) To bring home to manufacturers the advantages of research with the view of promoting the establishment of private, corporation, and group laboratories.

(h) To make and publish a census of available research facilities in men and equipment.

(i) To survey the natural resources of the nation and direct research toward their development.

(j) To appraise our great industrial wastes and develop plans and methods for turning them to profitable use.

As regards any research laboratory, it goes without saying that it is the personal factor which determines performance and this is preeminently true of the laboratory director. Sir Humphrey Davy truly said that his greatest discovery was Michael Faraday, and no greater problem is likely to confront a research laboratory than that involved in the discovery of a director. Successful laboratory directors may be of several types, but a militant optimism, contagious enthusiasm, controlled imagination and quick human sympathy are common to them all. Such a man will naturally in selecting his subordinates look for these personal qualities almost as carefully as he will weigh specialized scientific training, and having been thus guided in his selections will find it relatively easy to inspire throughout his organization those relations of good fellowship and that esprit de corps which multiply enormously the effectiveness of any working force.

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*Abstract of a paper presented at the Spring Meeting, Detroit, Mich., June, 1919, of The American Society of Mechanical Engineers.

The so-called commercial laboratory devoting its efforts to industrial research and operated on a strictly business basis will best serve our present purpose, and that of Arthur D. Little, Inc., in Cambridge, Mass., will be taken as a type in the belief that much of interest will be found in this establishment, which is "dedicated to industrial progress." During the past 33 years this laboratory has grown from a partnership of two chemists to an organization of sixty people, and scheme after scheme has been devised for the management of the enterprise, only to find new conditions and rapid growth calling for constant revision. Being a corporation, it is managed by the usual officers with a board of directors, all of whom do not devote their entire time to the business.

The Divisions of the Laboratory.—Within such a laboratory there are two distinct sets of duties which may be designated as scientific or technical, and commercial or financial. These two divisions have at least two points in contact, one being through a service manager, and the other the department charged with obtaining new business for the organization.

The fundamental duty of the scientific division is to interpret the results of pure science in the terms of industry. While the work of the commercial laboratory is of the same order as that done in any laboratory even where the dollar is never discussed, it must be conducted with full recognition of the fact that many industrial problems are as intimately concerned with economic questions as with scientific. In other words, while for instance a laboratory process in glass may be intensely interesting and of fundamental importance, the client can hardly be expected to be satisfied with a report unless a commercial method for operating it can be devised. The technical work should be in charge of the president, under whom various departments should be organized, so that each phase of a given problem may have the attention of a specialist, provided with adequate equipment to facilitate the work.

In this connection it may be emphasized that it pays to provide congenial, inspiring surroundings for the laboratory worker. The laboratory can be made attractive without being ornate, or involving unreasonable expense, and every effort should be made to have the workers reasonably happy. Under no other condition can the best work be expected, and it must be remembered that the heaviest investment is in the time of these workers, the salary cost being much greater than that for equipment or material maintenance. Rewards other than monetary for faithful service also play an important part.

The departments into which the technical division are divided will naturally differ in each laboratory, but a fairly definite line can be drawn between research, engineering and standardized or routine work. It is advantageous to have all of the standardized work, including that incident to research and engineering, carried on under one department head, for in this way it can be done to better advantage both as regards efficiency and economy.

The research department should be organized for both laboratory and small-factory-scale work. There will be a multiplicity of subjects, and since special faciliities cannot be provided in advance of close acquaintance with the problem, the organization of departments for research along special lines will concern personnel more than a division of floor space or equipment.

Engineering will embody plant inspection, design, construction and operation, and, although much of the work will be in the field, many phases of its problems will be worked upon concurrently in the laboratory.

The analytical department will be subdivided under such headings as textiles, fuels, food, metallurgy and metallography, chemical microscopy, water, lubricants, construction materials, pulp and paper, fermentology, etc. Some of these subjects will require special accommodations, while others can share a large laboratory which provides space for certain apparatus kept in place for a large number of similar determinations.

Nothing is more expensive or demoralizing than experimentation in the plant. An industrial research laboratory should therefore be adequately provided with equipment of semi-commercial size. Infant mortality among processes is high in any case and the most critical period in their young lives is that covering the transition from the laboratory to the plant. They require and the research laboratory should provide a nursery to protect and foster them during this period of their development. Some large manufacturers have even found it desirable to operate in connection with and under the sole direction of their research laboratory a small plant in which actual commercial manufacture is regularly conducted. Such extension of the laboratory's function permits the complete reduction to practice of new methods and the commercial demonstration of the sufficiency of the product before the innovations are introduced into the main plant.

Even when no such provision appears feasible, it is, nevertheless, highly desirable to have the industrial research laboratory actually engaged in some small scale, highly specialized, commercial manufacture, preferably of some product which it has itself originated. The least advantage of this procedure is that such manufacture of a properly selected product may frequently defray a substantial proportion of the expenses of the laboratory. The major benefits are the acquirement of a certain commercial sense by the laboratory staff, an appreciation of the conditions and difficulties of actual production, and finally the strengthening of the position of the laboratory through the increase in its turnover and equipment.

The Method of Management.—It is easy to visualize the organization chart for such a laboratory, and a brief description of how a new piece of work will be handled may therefore convey a better idea of the method of management. The authorization for the work will go to the service manager, who sees all incoming mail, and to the authorization will be attached any correspondence or data bearing on the case, all of which will be given a case number for identification, and this number will be entered in a case register, which will indicate the name of the client, the subject of the problem, the date the authorization is received and the date when the work shall have been completed. The service manager, who must be familiar with the ability of each member of the staff, as well as with the work in hand, will assign the case to the division which can render the best service. Conferences will then be called, into which any member of the organization who can contribute anything to the solution of the problem in hand will be drawn, and outside associates or independent consultants may be included. The problem will then go into work by means of instruction sheets, setting forth what is to be accomplished, suggesting methods of attack, relating any special circumstances, references to literature, and standard methods which may be applicable, and as much light as possible given to the individual who is to do the work. Accompanying the case there will be a tag bearing the case number and upon it a date at which it is expected the work can be completed, or a progress report made, must be indicated. The tag is then returned to the service manager. Through the means of data sheets, time slips and verbal reports the progress of the problem will be readily followed. This procedure will be followed in all the divisions, the individual reporting to his superior, and the service manager will be alert to insure prompt and efficient service to all clients.

At the completion of the work the report, varying in extent from a single printed form to a bound volume of several hundred pages, will pass through the hands of all concerned, and will thus be distinctly the report of the organization and not of an individual in the organization.

Reports.—Writing a report requires skill, for it must be comprehensive. It should begin with a clear statement of the problem, followed by the conclusion reached as a result of the work, which may then be described in detail. Patents, cost data, tables, graphs, photographs and samples should be dealt with in an appendix, and in some instances descriptions of apparatus should be included. The whole must be carefully indexed, and a copy sent to the library to be bound and kept as confidential information in locked cases, but as part of the library it should be carded for the library card index. Obviously no fast rule can be laid down for writing reports, but it should be borne in mind that many of those who read technical reports are not interested in minute details, and that the subject-matter must be presented in a form that will be interesting and understood by the layman. It must also have its important points so emphasized that they can be readily picked out by those not caring to read the entire report, but at the same time it should include sufficient data to serve the purpose of a fully qualified technical man to whom the report may be referred at some later time.

This brings up the question of the library, which may easily be considered the backbone of the industrial laboratory. Its extent will depend upon other library material available in the community, but there are few things which obstruct research more seriously than the absence of easily accessible proper library facilities. A few dollars spent in books and literature frequently saves as many hundreds otherwise spent in work of duplication. The useful periodicals must be provided, elaborate indexes will be found a good investment, also abstracts and patents; in short, every means for quickly locating literature references should be at hand. The current literature, with articles of interest indicated on an attached slip, should be circulated among the members of the staff whose names are checked on this slip, and some one, preferably a chemist, should have assigned to him the task of constantly reading the literature in order that no scrap of information shall escape.

The Lives of Engineers and Inventors

In connection with the memorial sketch of James Watt, which appears on another page in this issue of the Scientific American, we are led to recall a wholesome custom of one or more generations ago which we are afraid has been allowed to lapse. At one time it was not infrequent for lads of mechanical tastes to receive as presents from parents or others interested in their welfare that interesting series known as "The Lives of the Engineers," written by Samuel Smiles, an English author of considerable versatility and vogue.

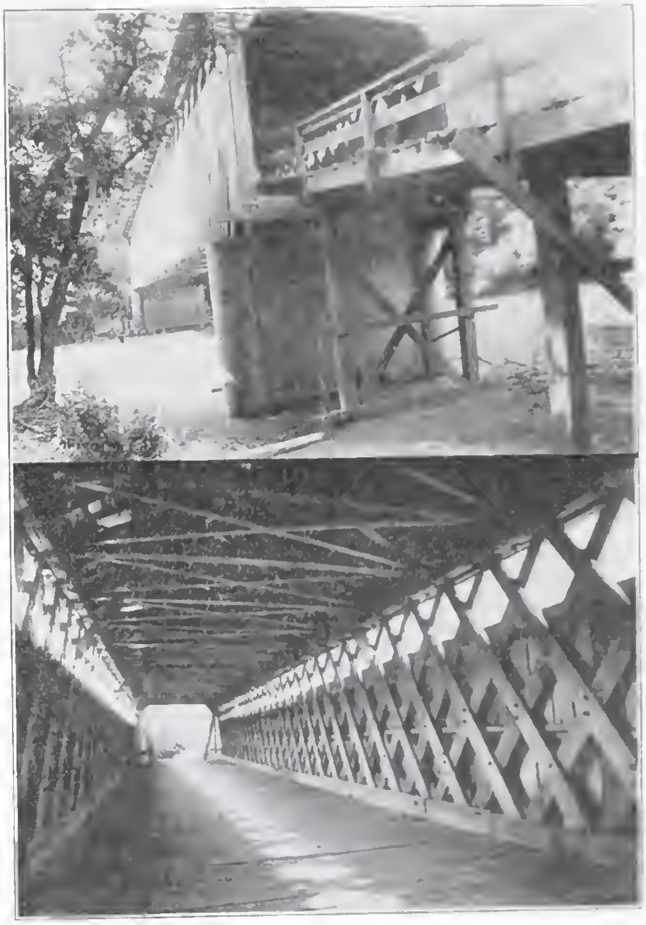
The biographies of Watt, George and Robert Stephenson, John Smeaton, John Rennie, Thomas Telford, and other engineers, had an attraction for an earlier generation, which is readily explained when it is considered how much British industry and civilization, and indeed that of all Europe and America, owed to the men who invented the steam engine, the locomotive, the steamboat; who built such structures as the Thames Bridge, the Eddystone Lighthouse and the Caledonian Canal.

The record of the lives of these rugged British worthies is directly inspiring and helpful, and while such books may be out of fashion today, we are convinced that their perusal would be of incalculable value to many a youth entering on manhood. The story of perseverance, genius, industry and integrity, is one that is compelling in its interest, and while the world and its conditions may have changed, humanity remains inded the same. Though mechanical problems may be new and the tools different, more complex and more highly developed than those of Watt and Stephenson, yet the solutions are to be found in the same clear thought, singleness of purpose, intense application, trained mind and hands, and study of the men and accomplishments of the past, that characterized these early engineers and inventors.

For the more modern engineers, unfortunately, there have appeared few biographers who have been able to write with such interest and facility as Samuel Smiles, or command his audiences; but in the modern attempt to emphasize the cultural side of engineering the study of the lives of men of creative genius is no less helpful than the mere consideration of their works. Although the materials of their constructions may rust and crumble, yet the spirit of such men never dies. Leonardo de Vinci as an inventor, architect and engineer, was no less an influence than as a painter, while Washington the surveyor and mill builder is no less an actuality than Washington the soldier and statesman. Is not the general public far too prone to look upon inventors, engineers and scientists as eccentric geniuses, and, while recognizing their usefulness consider as typical men of unusual and picturesque attributes rather than those who have led well disciplined, studious and efficient lives? Would not a more general reading of the biographies of men who have established vast industries through mechanical inventions and vast works of construction be of the greatest value to a rising generation, and would not the lives of many modern workers in applied science be for the sympathetic biographer a profitable and congenial field that far too long has remained untilled? May not the Scientific American bring to the attention of its readers the importance of reading such biography, and bespeak in particular a more careful consideration of the lives of the great inventors and engineers?—Editorial in the Scientific American

Cost of Covered Wood Bridge

A "housed-in" pin connected wood truss bridge was erected last year in Lowdnes County, Mississippi, at a cost approximately one half the price bid on steel and concrete structures of the same dimensions. The bridge has a total length of 125 ft., with a distance between piers, c. to c., of 112 ft. The floor width is 16 ft. The concrete piers are set on piles 10 ft. below low water. The work was done by contract the costs to the contractor being as follows:



Housed in Pin Connected Wood Truss Bridge Constructed in 1918 in Lowndes County, Mississippi

Materials:	
Lumber, 38,600 B. M. ft., at $22, delivered	$[illegible]
Shingles, 24,000, at $5, delivered	[illegible]
Bolts and washers	[illegible]
Reinforcing steel, 2,[illegible] lb., at [illegible]	[illegible]
Nails, 700 lb., at [illegible] ct.	[illegible]
Cement, 180 sacks, at $0.75	[illegible]
Hardwood pins tallowed, 1,2[illegible], at $0.[illegible]5	[illegible]
Concrete forms for piers	[illegible]
Piles, 20, round, 8 in. by 10 ft., at $2	[illegible]
Total materials	$1,8[illegible]
Labor: Including mixing 36 yards concrete. Approximately	[illegible]
Total	$2,[illegible]
Contractor's profit	[illegible]
Grand total	$2,[illegible]

The contractor salvaged an old bridge from which he got material worth $100.

The bridge spans the Buttahatchie River. It was built jointly by Lowndes and Monroe Counties, Mississippi the engineer being Mr. C. L. Wood, County Engineer of the first mentioned county. Mr. Wood states that he knows of two similar bridges, built of heart lumber, which are still in use after 60 years' service.

The Inspection of Steel Bridges

Every railroad necessarily has some system of steel bridge inspection, and many different officers of the maintenance of way department are concerned with this work in one way or another. Bridge carpenters are held responsible for at least the condition of the decks, and in many cases for the minor steel structures in their entirety. Some roads employ special bridge inspectors who are engaged in this work the year around, others depend upon periodic inspections by certain officers. In many cases the bridge engineer himself makes detailed inspection of all bridges of any importance. Almost any man having anything to do with bridge work will recognize a defective condition when he sees it, but it is not everyone who has had enough experience to enable him to be sure that he will find everything that should be noticed. Effective bridge inspection implies a training in systematic examinations and a knowledge of where troubles are likely to be encountered and how to look for them. A useful outline of the things to look for in examining steel railroad bridges of various classes is given by Mr. G. A. Haggander, Bridge Engineer of the C., B. & Q. R. R. in a recent issue of The Railway Maintenance Engineer, from which the matter in our article is taken.

General Details.—On arrival at the bridge make a general visual examination of the alinement and surface to see if it will disclose any serious settlement in the substructure, displacement of the superstructure on the substructure or faulty condition of the camber.

On all through girder bridges and all pony truss spans, sight along the top flanges or chords to see that they are perfectly straight. Owing to the absence of a top lateral system these compression members are not stayed rigidly against buckling, so if they are to function properly it is essential to have them in good alinement.

Note the condition of the paint on the bridge.

The Deck.—Examine the running rail to see that it is fully spiked and bolted and that there are no broken rails or splice bars. See that no spikes are driven through the slots in the splice bars or close to the ends of them. The rails should be free to run across the bridge. See that the inside guard rails are fully spiked and bolted. When changing ties trackmen are inclined to slight fastenings in the guard rails, but insufficient fastening should not be permitted.

Examine the condition of the timber in ties and outside guard rails or fenders and note any decay or crushing, particularly in the ties. See that the tie bolts and bolts in the fender are in place and that the nuts are not missing on the position of the tie bolts.

Note the condition of the top flanges of the girders or stringers and floor beams. These are particularly susceptible to corrosion on lines subject to heavy refrigerator car traffic.

Deck Girder Spans.—In addition to this detailed examination from the deck examine all members of the top lateral system, tapping the bars to see that they are tight and insure that the top lateral plates are securely fastened to the girder flanges.

The bridge seat must be clean of all debris of any kind. See also that the expansion end is free to move with changes in the length of the girder. Insure that there is a sufficient clearance between the end of the girder and the back wall for adequate movement and that there are no rivet heads on the end of the bottom cover plate that will foul the edge of the bearing shoe. If the bearing is equipped with rollers, see that they are in proper position. Make sure that there are no broken pedestals or shoes. Be sure that all bolts connecting the girders to the bearing castings and connecting the bearing castings to the masonry are in place.

In cases where the girders of a bridge on a curve are tilted to obtain super-elevation, one side of the flange on each girder will form a trough that will hold rain water. If there is any evidence that water is being held in this way, it will be well to fill this trough with some bitumen mastic.

Through Girder Spans.—Examine the deck and bearings of the bridge as described above, but in examining the deck note in addition whether the ties have crushed down to such an extent as to bring the underside of the rail in contact with any rivets or other projections on the tops of the floor beams. Such a condition should not be allowed to continue, as it would lead to dangerous rail strains.

Test all rivets connecting the floor beams to the girders and all rivets of accessible connections of the stringers to the floor beams. Particular attention should be paid to the stringer connections. Look for cracks in the stringer and floor beam connection angles. These ordinarily form in the root of the angle at the top. The bottom lateral system should be tested with a bar of iron or other convenient tool.

Truss Spans.—Examine the deck and bearings and floor system complete as described above. In addition walk the bottom chords from end to end and examine them carefully. Shake all of the eye-bars in the chords to note their adjustment. In a similar manner try all lateral members and web diagonals. Eye-bar or loop rod hip verticals should also be examined carefully, as these are frequently out of adjustment.

There are still a few old bridges having the floor systems suspended from the pins by means of U-hangers over the pins. These should be examined carefully to see that they are in adjustment and that the nuts are secured in place.

Examine all pins to be sure that the nuts are in place. Where any loop bars are used, be sure to see if any of them indicate signs of splitting, and if this is the case arrange for clamps immediately.

Swing Spans.—Examine the deck, floor system and trusses in detail as described above and look especially at the cross ties at the ends of the span under the rail locks and for worn pins at the end bearings. In examining the bridge seat of the end bearings look for broken castings especially, and see if there is any uplift of the bridge when a train is entering the span at the far end. See that the rail locks operate satisfactorily and that they are not worn excessively.

Go down on the pivot pier and walk entirely around the drum. Examine the segments of the rack and tread to look for broken teeth, and also to see that the wear on the tread and the rack is uniform all the way around. See that the tread is smooth and well oiled and that all wheels are bearing. Also examine the pinion. Go down inside the drum to see if there are any broken radial rods and make an inspection of the gear train from the motive power to the pinion.

Turntables.—Examine the deck and girders for defects as in the case of other bridges. Look over the end carriages and note the condition of the bearing boxes and whether or not the wheels have chipped, broken or worn treads. The beams, which are usually a pair of channels, should be examined carefully to see if they have become twisted or broken. See that the circle rail is in good alinement and surface and that the end carriage wheels clear it all the way around when the table is loaded. If the alinement is not good there is danger that the end wheels will have an eccentric bearing, causing the edges to chip and that the tractor will work hard.

The condition of the rails and ties at the end of the table, both on the table and on the coping, must be watched carefully. See that the gaps between the ends of the rails does not exceed 1½ in. The rails, both on the table and the coping, must be thoroughly anchored. Ties crush very quickly from the pounding of the wheels in going on and off the table and heavy plates covering the ties and the coping will be found to be a big help.

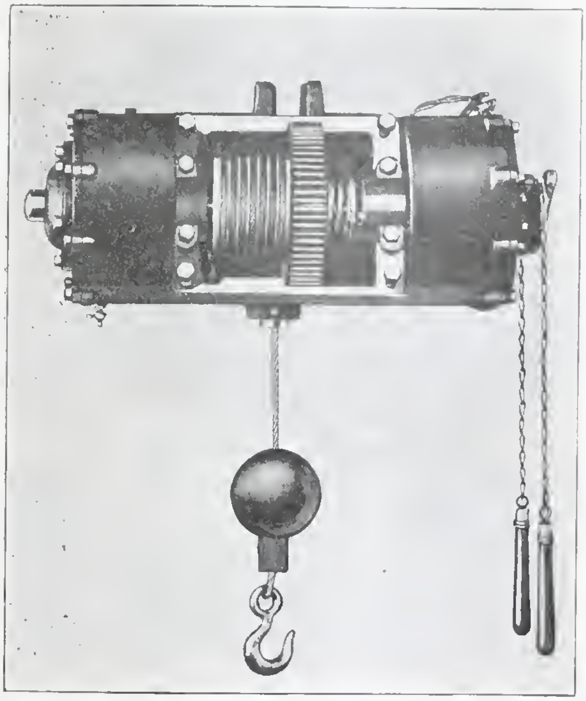
The turntable center needs careful attention and as this is not accessible, the table should be jacked up from two to four times a year so that the center may be taken apart and examined thoroughly to see that it is being lubricated properly and that the wear has not been excessive. The condition of the turntable foundation should also be checked carefully by turning the table in different positions to see if there is any tendency for it to rock.

Viaducts.—The deck, girders and abutment bearings of the viaduct should be examined as described above for girders and truss spans. Particular attention should be given to the condition of the connections of the girders to the tops of the columns to insure that the bolts are in good condition and the nuts in place.

A careful examination should be made around the bases of all the towers and bents. Look for defective connection and anchor bolts and cracked column shoes. Also examine the masonry pedestals carefully to insure that the uplift on the pedestals does not have a tendency to rupture the masonry.

New Hoist Particularly Adapted for Use in Restricted Space

A hoist designed specifically for the severest kind of industrial service has been perfected by Victor R. Browning & Co., Cleveland, O., after a long period of experimental development. The general shape and low design of the hoist adapts it particularly for use where headroom is limited or the available space otherwise restricted. The main casting, which carries all moving parts, contains individual compartments for the four units, any one of which can be quickly removed if desired. In one end of the casting, heat treated gears and the disc load brake are assembled and revolve in oil. At the reverse end, the controller and motor shaft are carried in another individual compartment. The entire controller may be quickly removed for inspection or repairs, and the removal of a plate gives access to the gears and load brake. Between the gear and controller units are two long compartments, one of which contains the motor and the other the hoisting drum. The drum is carried on a threaded shaft and travels longitudinally while rotating. This feeds the cable through a bushing in the main housing and directly into the drum groove in rewinding. It is claimed that this adds considerable to the life of cables and maintains perfect balance. Simple but dependable limit attachments are installed at ends of the drum shaft to prevent overtravel of the drum in either direction. All bearings are large and bushed with phosphor bronze with exception of the motor, the shaft of which revolves on ball bearings. Two of the bearings are provided with grease cups while the other four are lubricated by splash from the gears. The hoist is furnished with specially designed motor either D. C. or A. C. and provision can be made for suspending it from an overhead trolley, I-beam or any kind of fixture.



New Victor R. Browning & Co. Hoist.

A Railroad Pontoon Bridge

The Chicago, Milwaukee & St. Paul Ry. still maintains a pontoon bridge on its line—perhaps more than one. Between Pairie du Chien, Wisconsin, and North McGregor, Iowa, the Mississippi River is crossed on a pile bridge and an island, a mile in length. In each of the two channels pontoons are maintained, so attached that they can be swung by means of a cable winding by steam power on a drum, to allow boats to pass.

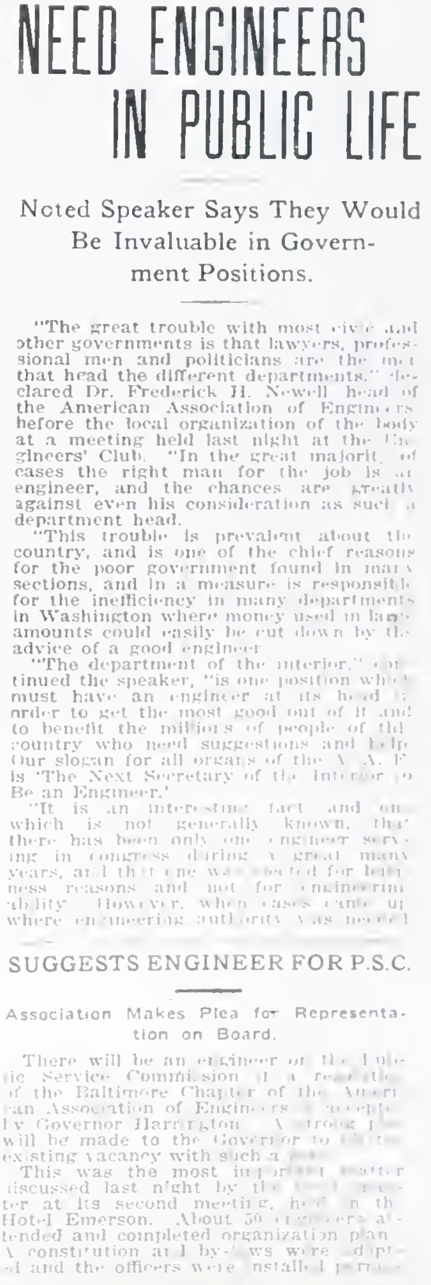
Pontoons have existed at this crossing for 45 years. The latest channel span consists of a hull 274 ft. long and 56 ft. wide. On the upper deck nineteen columns of 9-inch blocks rise on each side, supporting the upper deck on which the tracks are built. The problem is, of course, to maintain this upper deck on a constant level, even with the pile approaches, regardless of the height of the water. By means of cables the weight of the track is lifted from the blocks, and blocks are then inserted or removed as the level of the water requires. The finished height of the middle portion is always left 9 in. higher than the level of the approaches. The end steel girders from the approaches to the pontoon are hinged to allow for this difference. The weight of the train sinks the outfit just this much as it travels over.

Ice gives considerable trouble. Most of it passes under the scow, but an unusual amount is freed by swinging the hull. Closing of the channel by swinging the pontoon back is often very difficult under the circumstances.

Two small openings in the pile approaches assist in getting rid of the ice and also in allowing smaller vessels to pass. Troubles of any kind are now negligible, although in earlier days delays of hours and seven days were not unknown.

Newspaper Publicity for the Engineering Profession

Examples of the newspaper publicity obtained by some of the chapters and clubs of the American Association of Engineers are shown below. The longer extract, furnished by the Dayton Chapter, is particularly good as it points out to the public the necessity for the administration of public works by engineers.



NEED ENGINEERS IN PUBLIC LIFE

Noted Speaker Says They Would Be Invaluable in Government Positions.

"The great trouble with most civic and other governments is that lawyers, professional men and politicians are the men that head the different departments," declared Dr. Frederick H. Newell head of the American Association of Engineers before the local organization of the body at a meeting held last night at the Engineers' Club. "In the great majority of cases the right man for the job is an engineer, and the chances are greatly against even his consideration as such a department head.

"This trouble is prevalent about the country, and is one of the chief reasons for the poor government found in many sections, and in a measure is responsible for the inefficiency in many departments in Washington where money used in large amounts could easily be cut down by the advice of a good engineer.

"The department of the interior," continued the speaker, "is one position which must have an engineer at its head in order to get the most good out of it and to benefit the millions of people of the country who need suggestions and help. Our slogan for all organs of the A. A. E. is 'The Next Secretary of the Interior to Be an Engineer.'

"It is an interesting fact and one which is not generally known, that there has been only one engineer serving in congress during a great many years, and that one was elected for business reasons and not for engineering ability. However, when cases came up where engineering authority was needed

SUGGESTS ENGINEER FOR P.S.C.

Association Makes Plea for Representation on Board.

There will be an engineer on the Public Service Commission if a request of the Baltimore Chapter of the American Association of Engineers is accepted by Governor Harrington. A strong plea will be made to the Governor to fill the existing vacancy with such a [illegible]

This was the most important matter discussed last night by the local chapter at its second meeting, held in the Hotel Emerson. About 50 engineers attended and completed organization plans. A constitution and by-laws were adopted and the officers were installed perma-

Personals

Frank B. Roth has been appointed chief engineer of the Lehigh Structural Steel Co., Allentown, Pa.

J. H. Knowles has been appointed chief engineer of the Western Pacific, Tidewater Southern and Deep Creek railroads.

The Utah-Idaho Development Co. of Ogden, Utah, has been incorporated. The officials include David C. Eccles and Warren L. Wattis.

Rodman Wiley has resigned as commissioner of public roads of Kentucky to become chief engineer of the Kentucky Rock Asphalt Co., of Louisville, Ky.

Charles R. Simpson and Ralph M. Brown have organized the Simpson, Brown & Co. and will engage in a contracting business with offices at Elizabeth, N. J.

Lieutenant B. C. Tilley, 104th Engineers, A. E. F., has just returned from France and accepted a position with Pacific Gas & Electric Co. of San Francisco, Calif.

Carl Bergstedt, Carl G. Johnson and Ed. Andries have organized the Bergstedt Construction Co., with offices at 202 Berglund Block, Moline, Ill., and will engage in a general contracting business.

Prof. Milo S. Ketchum, dean of the School of Engineering at the University of Colorado, has resigned to become head of the department of civil engineering at the University of Pennsylvania.

Capt. August Weber, fomerly connected with the T. M. Wichert Company, contractors and engineers, of Pittsburgh, has been appointed general manager of the Gwynns Falls Quarry Co., Baltimore, Md.

Walter Clark has been elected president of the recently incorporated Liberty Engineering & Construction Co., Murchison National Bank Bldg., Wilmington, Del. The other officials include E. L. Phillips, I. A. Page and H. W. Nutt.

Louis C. Bennet, James N. Gladding, Columbus E. Mauldin of Albuquerque, N. Mex., and Wm. H. Springer of Venice, Calif., have organized the Southwestern Construction Co. of Albuquerque and will engage in a general building and contracting business.

J. A. Balderson has been placed in charge of the A. F. E. office of the Chicago, Milwaukee & St. Paul R. R. and the work of compiling and keeping the records required to carry out Valuation Order No. 3, vice C. H. Poole, resigned to enter into private business.

Clinton Cowen has resigned as state highway commissioner of Ohio and has accepted a position as consulting engineer for the National Sand and Gravel Association. A. R. Taylor, formerly county surveyor of Hancock County, Ohio, succeeds Mr. Cowen as state highway commissioner.

J. W. Kaerth, formerly County Surveyor of Colusa County, California, has opened an engineering office at 611 Market St., Colusa, Calif., and will specialize in reclamation and irrigation work. Associated with Mr. Kaerth is George H. Meck, who has been identified with various reclamation projects in the Sacramento Valley.

Anglin-Norcross, Ltd., building contractors, Montreal, Que., has been formed by the amalgamation of Norcross Brothers Co., Worcester, Mass., and Anglin's, Ltd., of Montreal and Toronto. The officers are J. Penrose Anglin, B.Sc., president; Mr. Henry J. Gross, late of Norcross Brothers Company, vice-president, and Mr. C. D. Harington, of Anglin's Ltd., managing director.

The Kelvin Engineering Co., Inc., Gustavo Lobo, President, Engineers and Contractors, 32 Broadway, New York, has organized a new department to do general engineering and contracting work in this country and in Latin America. This department will be in charge of Carlos Lobo, formerly borough engineer, Department of Water Supply, Gas and Electricity, Borough of Brooklyn, New York.

J. J. Long, formerly asisstant professor of Civil Engineering of the University of Cincinnati, has been promoted to be professor of industrial engineering. Edgar K. Ruth, who was a captain and chief gas officer at Fort Sill, has returned to his work as assistant professor of civil engineering. Charles S. Carroll, his substitute, will be continued permanently as assistant professor of civil engineering.

Wilbur M. Wilson has been appointed associate professor of structural engineering in the College of Engineering at the University of Illinois. Other new appointments to the staff include the following: Joseph E. Burgess, associate in freehand drawing, and Chauncey R. McAulis, instructor in architectural engineering, in the department of architecture; Ernest Langford, Bernard Smith and Harry S. Donald, instructors in general engineering drawing.

Allen Pierce Richmond, Jr., has been appointed assistant professor of civil engineering in the Thayer School of Civil Engineering at Dartmouth College. Mr. Richmond was graduated from Dartmouth College in 1914 and from the Thayer School in 1915. During the next two years he was with the Central Aguirre Co. at Central Aguirre, Porto Rico, engaged upon general engineering work in connection with a sugar plantation. In 1917 he enlisted in the army and was commissioned first lieutenant, Field Artillery Reserve Corps. During the last part of 1918 he was in France. He returned recently from work with the United Fruit Co. in Cuba.

News Letter

St. Louis Items

Cook & Stucker are getting along nicely with their street paving job at Harper, Kan.

The Walsh Const. Co. have 150,000 yards of machine and team work to let at Union City, Ind.

M. Hayes & Sons expect to finish their work at Jewett, Ill., in a few days. Will have a 20 team and machine outfit idle.

Fruin & Conlon Const. Co. were awarded the contract for the new St. Louis Coke & Chemical Co. plant in Edwardsville, Ill.

Dunn-McCarthy Co. has finished its big grading job for the General Motors Co. here on Union Ave. and Natural Bridge Road.

Henry Schweitzer writes us from Marion, Ill., that he has a 1⅝ yard steam shovel, 15 teams, wagons, scrapers, etc., idle at that point.

Jerry Connors completed his contract on the General Motors job here last week and is working some of his teams by the day on extra work. Has shipped a part of his outfit on to a reservoir job at Ashland, Ohio.

We are in receipt of a notice from John Marsch stating that the officers of John Marsch, John Marsch, Inc., the Wisconsin & Michigan R. R. Co. and the Beaver Iron Co. have been removed from 105 S. La Salle St. to 1307 Wrightwood Ave., Chicago. Their new phone number is Diversey 2635.

Capt. A. W. Farney entertained a number of Kansas City contractors on his farm with a barbecue and moving picture show last week. After the festivities they had a mock trial at which J. W. McMurray was accused of taking a contract at too low a price. The jury found McMurray guilty and sentenced him to tell a funny story and to sing a song. McMurray told the funny story all right, but his singing was so rank that the judge and jury remitted this part of the sentence and finished the singing themselves.

P. J. Hannan Co., who have the general contract for building an extension of the Ft. Smith-Sabiaco & Rock Island R. R., have sublet their work to the following contractors: D. H. Duffey, Buck Norfleet, Tom Cain, W. M. Werden, J. J. Parsons, Daniels & Rogers. The pile driving and team work was let to E. Y. Sutherland, while Trainer & Williams are going to do the concrete work. Everything is progressing nicely on this line under the able management of Ben Reynolds. The old veteran dirt mover, Tom Cain, is leading all the team outfits in the amount of dirt moved to date and Tom has such a lead now that it will be very hard for any of the other outfits to catch up with him. Track laying started on the work last week and the P. J. Hannan Co. expect to complete the work way ahead of contract time.

A. B. KOENIG.

Industrial Notes

The Engineering Advertiser's Association of Chicago has been organized by a group of men actively engaged in the production end of advertising work, including H. L. Delander of the Crane Company, P. A. Powers of the Benjamin Electric Mfg. Co., Glenn H. Eddy of the Green Engineering Co., J. J. Arnsfield of Fairbanks, Morse & Co., and Albert H. Hopkins of the C. F. Peace Co. Membership in the organization is limited to advertising and sales executives of concerns engaged in the manufacture of engineering products.

The Barber-Greene Co., Aurora, Ill., recently began work on the construction of a 180x90 ft. addition to their factory. This is the second time this year that additions have proved necessary in keeping up with orders. The new building will be used as the assembly department and will be modern throughout. Re-inforced concrete with continuous sash windows, steel trussed roof, railroad track and loading platform inside walls are a few of the features incorporated in the design. The Federal Bridge Co. of Waukesha, Wis., was awarded the contract for the steel work and the remainder is being handled by the Barber-Greene Co itself. It is hoped to have this work finished within 60 to 90 days.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Pipe.—National Tube Co., Pittsburgh, Pa. 10 page bulletin describing the manufacture of "National welding scale free pipe."

Building Construction.—Blaw-Knox Co., Pittsburgh, Pa., 40 page catalog illustrating and explaining the equipment used and the methods employed in the Blaw System of floor, roof and column construction in reinforced concrete.

Unit System Steel Buildings.—Milliken Brothers Mfg. Co., Inc., Woolworth Bldg., New York City. 44 page catalog describing the standardized truss unit system buildings designed by the company. The same company also has issued a 32 page catalog containing foundation plans, erection diagrams, construction details and directions for erecting the buildings.

Obituaries

Thomas McNally, president of the Monongahela Construction Co. and Thomas McNally & Son Co., died suddenly at his home, 5531 Hays street, East End, Pittsburgh, Pa., Aug. 24. He was born in Pittsburgh Oct. 8, 1858. He began his business life as a newsboy in 1864; continuing in this until 1870, when he began steamboating from Pittsburgh to New Orleans, working as cabin boy, deck hand and lamp trimmer, until 1877, when he quit the river and went to work as a laborer on the construction of the Pittsburgh & Lake Erie R. R., shortly afterward being made foreman of pile driving and trestle gang. He went into the sub-contracting business in 1881 and constructed the present B. & O. R. R. trestle from Federal street to Woods Run, in Pittsburgh. In 1883 he went with Booth & Flinn on general contracting, and on leaving them in 1889 began business for himself and has executed some very large contracts, among them being: Over 400 miles of street railways in Rochester, N. Y.; St. Louis, Mo.; New Orleans, La.; Indianapolis, Ind., and Pittsburgh, Pa. Two miles of double track trestle, Pittsburgh, McKeesport & Y. R. R. Piers and foundations for McKeesport suspension bridge, Seventh street bridge and Thirty-third street bridge, Pittsburgh, Pa. Laid and placed in the streets of Pittsburgh and vicinity 75 miles of natural gas mains. Had a force of 9,000 men in Johnstown, Pa., after the flood, cleaning up streets, pulling down dangerous buildings and leaving the town so that business people could erect temporary business houses. Constructed Beechwood boulevard from Schenley Park to Highland Park. Constructed the Cumberland branch of the Pennsylvania R. R. from Kennelworth to Chester, W. Va. Constructed the Hazelton yard from the P. & L. E. R. R. Executed for the Montour R. R. a large rock cut at Coraopolis, Pa. Constructed 400 coke ovens at Footedale, Pa. Completed 150,000 yards of heavy rock work, leveling up property for the Homewood Cemetery. Constructed Schenley Park race track. Developed the Vesta Coal Company plant at California, Pa. Changed line and grade, Pennsylvania R. R., at Pack Saddle, Pa. Changed line and grade, Big Four R. R., at Danville, Ind. Constructed Franklin & Clearfield R. R. bridge over the Allegheny River at East Sandy, Pa. Changed line and grade on Morgantown & Kingwood R. R. Constructed and changed line of four tracks between Ryde and Vineyard on main line, 55 miles east of Altoona, Pa. Was awarded first contract on New York aqueduct amounting to approximately $5,000,000. Constructed $2,000,000 worth of work on New York barge canal. Constructed two bridges for P., F. W. & C. R. R. near Mansfield, O. New road for Pittsburgh at Tuberculosis Hospital. Construction of Spencer street, Pittsburgh, from Lincoln avenue to Upland street, including concrete bridge. He was married in 1889 and is survived by his widow, one daughter, Mrs. Frank Spuhler, and one son, Sellers McNally.

Road and Street Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field if subscribed for as a weekly at $3.00 a year; but any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year (or any two monthly issues at $1.50 a year) and the 4 special quarterly issues will be sent without extra charge. Three of these special quarterly issues relate entirely to foreign engineering and construction practice, and the fourth is our annual "New Equipment Issue." The *articles* in the first two issues of each month (1st and 2nd Wednesdays) completely cover the municipal engineering and contracting field. The *articles* in the first and last issues of each month (1st and 4th Wednesdays) completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and last issues of each month (3rd and 4th Wednesdays) completely cover steam and electric railway location, design and construction. See the "mast head" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials

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Disarm the Strike-Toting Railroad Brotherhoods

The first quarter of this century will be noteworthy because of the rapid development of industrial, commercial, agricultural, and professional associations. We are living in an age of "organization for mutual benefit." At the present moment we are witnessing the beginning of great conflicts between organized classes of men. For example, the California Raisin Growers' Association, having raised the price of raisins several hundred per cent, is being attacked by the California Wholesale Grocers' Association, on the charge of profiteering. If there were such a body as the Raisin Eaters' Association, it would probably be waging war against both the raisin growers and the raisin wholesalers, not to mention the raisin retailers. As a matter of fact, there are housewives' leagues, of one sort or another in many cities and they probably are the forerunners of numerous consumers' associations that will spring into existence throughout the country, for organization to increase profits leads to organization to reduce profits, as surely as the submarine leads to the depth bomb.

An age of "organizations for mutual benefit" inevitably ushers in an age of conflict, for what is beneficial to one class of men as a class is apt to be injurious to other classes. The age of industrial conflict has already begun. It will not end until the government becomes sufficiently aroused to end it.

In the pioneer days of this country every man was a "gun toter," and therefore a potential duelist. Base murders, gentlemanly duels, and "necktie parties" were of common occurrence in every community, until in desperation local governments made it a public offense to carry concealed weapons. The concealed weapons of today are "the strike" and "the profiteering price." How long will organizations of workers and producers be allowed to carry such weapons of offense and defense?

In the proposed Cummins bill to regulate the railways, we have the first serious attempt to disarm one of the greatest organizations in America—the railroad brotherhoods. A dozen years ago the railways themselves were disarmed by the law that gave the Interstate Commerce Commission the power to regulate railway rates, and thus prevent profiteering by capitalists in the railway field. At that time we pointed out that the ultimate result would be the control of railway wages by the government and the prohibition of strikes. The public has been slow to recognize that if railway capitalists are to be disarmed, railway employes must also be disarmed. When the profiteer pistol is taken from the capitalist, the strike pistol should be taken from his employe. This should be clear enough to an impartial outsider, but it is not yet evident to the union workman. The Coal Miners' Union has

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

just denounced the Cummins' bill as "the most pernicious piece of legislation ever proposed in Congress." The same sort of protest rose from the throats of thousands of "free Americans" when laws against carrying concealed weapons were enacted. "What right had a city or state to deprive an American of his only means of self-defense, his trusty six-shooter?" The answer was: Where battles between individuals or groups of men endanger the rest of the public, public welfare demands disarmament on the part of all except the police.

The Absence of Protest Against the Appointment of a Daily Paper Editor as a Superintendent of Public Works

A few weeks ago James E. Doyle, managing editor of the Syracuse Herald, was appointed deputy superintendent of public works of New York state. Announcing the appointment the Associated Press dispatch said: "Mr. Doyle immediately qualified for the position by taking the formal oath of office."

Did he? Didn't he really "qualify" to draw the salary of $5,500 a year, rather than "qualify for the position"? By what necromancy can an editor of a daily paper "immediately qualify" for any position involving a knowledge of transportation and construction economics?

A reader of Engineering and Contracting also asks a few questions:

"Would the New York Central R. R. Co. appoint a managing editor as superintendent of one of their operating divisions?"

"Is not the Barge Canal a transportation line?"

"What are the duties of a superintendent of public works?"

"Is the $5,500 salary the answer to query as to this anomalous appointment?"

Yes, the salary was one of the reasons; but the underlying reason is public ignorance of economic matters. If the public knew, as well as engineers and contractors know, the necessary qualifications of an efficient superintendent of public works, the appointment of an editor would be so severely condemned in editorials in the daily papers that the appointing official would lose prestige and ultimately lose his position if he did not listen to popular protest. But not a single editorial article in New York State has yet been written condemning the appointment of Mr. Doyle to the public position. It may possibly be that Mr. Doyle has had some experience that really qualified him for this position. It so, why is the public not informed of the fact?

The writer was at one time assistant New York State engineer, and at that time the superintendent of public works was the "political boss" of Monroe County. Under him were scores of inspectors of the construction work then going on along the Erie Canal; for the State Engineer did not have charge of the inspection of the work done by contractors. The result was lax inspection, from which followed charges of corruption that were leveled against the entirely blameless department of engineering. But the engineering force was regarded by the public as part and parcel of the inefficient department of public works, because it was natural to suppose that the men who designed the canal work were also in charge of its inspection. That experience taught the writer that engineers should always resent any division of authority by which they are not able to control the inspection of works that they design. Yet that vicious condition of affairs exists in many cities where "ward heelers" and other incompetents are inspectors of public works.

Engineers are at last becoming aroused to the necessity of educating the public to an understanding of the fact that a public office requiring technical experience should be held only by technical men. In conducting the campaign of education, engineering societies will do well first to educate the editors of the daily papers. To do this, something more than letter writing will be necessary. Committees of engineers should call upon editors of daily papers at frequent intervals, and persuade them to protest against unwise appointments. When a vacancy exists in any municipal department where technical training is needed, editors of local papers should be urged to write editorials that will influence the mayor or other appointing official to select a technical man.

In all large cities, and in many small ones, there are so many important economic problems to be solved by the Superintendent of Public Works, the Superintendent of Water Works, and the Superintendent of Street Cleaning, that such positions should be filled only by men of technical qualifications. It is not difficult to prove even to a "layman" that this is so, but it is hard to get an audience with many "laymen" save through the daily papers. Hence the wisdom of converting the editors of daily papers to belief in the superior qualifications of technical men for executive positions of the character above named.

Why President Wilson Named No Engineer as a Delegate to the Capital-Labor Congress

How meagre is the general appreciation of the economic importance of the engineer is exceptionally well illustrated in the failure of President Wilson to name a single engineer as a delegate to the capital-labor conference at the White House this week. Several dozen men from all walks of life will be there, and quite properly the representatives of labor and the employers of labor will constitute the majority. But why should there be none to represent the profession whose especial business it is to apply science in solving the problems of economic production and distribution? Why, for example, was Herbert Hoover not asked to be present at this great economic congress?

Our readers will recall that Engineering and Contracting was the first to suggest such an economic congress as is now about to take place. In an editorial entitled "Suggested Economic Congress of Workers and Capitalists of All Classes," Aug. 20, 1919, we said in part:

"Warren S. Stone and thousands of other labor leaders are prejudiced by their class consciousness to a degree that they do not realize. But while their prejudice leads them to avoid reading books and articles that would modify their views, we believe they are not so stubborn as to refuse to listen to facts were the facts presented by sincere men who advocate the capitalistic system.

"Inventors, engineers, managers, business men, bankers and all the vast host of mental workers should, somehow or other, present their experience and conclusions to the greater host of manual workers.

"Perhaps there should be an economic congress of all classes of men in America, each class represented by several delegates. At the sessions of this economic congress every class would have a chance to be heard, and a chance to question the representatives of other classes. For the first time in history, every class of worker, manual and mental, would be able to listen to every other class, to hear his facts and his inferences from them, to listen to his aspirations and his proposals for attaining them.

"It may be said that our two houses of Congress already give ample opportunity for such a conclave of classes. Unfortunately, however, our legislative representatives are mainly professional talkers, as is evident from the fact that most of them are lawyers. Talk from professional talkers we have had in abundance, but talk from the doers has been largely confined to their own circles. What is needed is talk from every class of doer to every other class. Let Mr. Stone, the unionist, for example, tell why he believes that profits and wages are inimical. Then let him hear Mr. Vanderlip, the banker, tell why and how the capitalistic system in America has made it possible for manual workers in this country to earn several fold as great wages as in Europe. Let Mr. Edison, inventor and capitalist combined, tell what inventors backed by capitalists have already accomplished, and give his forecast of what will be accomplished in the next fifty years under the capitalistic system."

Copies of that editorial were sent to the metropolitan dailies, and similar editorials then began to appear. The President's call for the capital-labor conference on Oct. 6 followed shortly thereafter. Perhaps this was merely a coincidence, but it seems probable that an editorial written by an engineer was the direct cause of this economic congress in which no engineer will have a voice.

In this connection we are glad to note that the American Association of Engineers has just issued a "Call to Unity of the Profession," published in another column, which should be read by every technical man. We quote one paragraph apropos of the capital-labor congress.

"The engineering profession today faces the danger of being submerged in the controversy between capital and labor. In its position between capital and labor the profession should be represented as a matter of course at the White House Conference in October. Any invitation that may be received will come, however, only on request, and the engineer who attends will be regarded only as an onlooker. We can have a voice and be heard only by presenting a united front."

New Jersey Sets Another Good Example by Paving Village Streets on State Highways

It would be well were all States to follow the example of New Jersey, which has recently undertaken to pave State roads within the limits of cities having a population of less than 12,000. Hitherto there have been many gaps in the pavement of main highways because small towns have frequently been negligent in paving the highways that pass through them. Towns in New Jersey have been no worse than those in other States in this respect.

Small towns have not been the sole offenders. There are scores of cities of more than 12,000 population that have allowed paved country roads to terminate in unpaved city streets. New Jersey proposes to enter into agreements with the larger cities whereby the State and the cities will share the cost of paving main highways within city limits.

Sacks of Cement for Concrete Mixes

To the Editor: In your issue of Sept. 3, page 277, you give a table of the number of sacks of cement required for different concrete mixes.

My own method is to add together the figures giving the mix and divide 40 by the sum; the quotient is the required number of sacks.

As an example, take a 1:3:6 mix. The sum is 10; 40 divided by 10 is 4, the required number of sacks.

The reason of course is that for 33 per cent voids the cubic yard contains 40 cu. ft. instead of 27.

In practice it gives a method of telling the contractor how many sacks to haul to each job without "looking in the book" and usually without a pencil.

J. A. MORROW,
Holbrook, Ariz. County Engineer.

Cost Plus Contracts

To the Editor: In your issue of Sept. 17, Mr. G. H. Hailey states that, in my letter which you published on July 2, I did not include in my list of different forms of contracts one which he terms "cost-plus-unit-profit" and which he claims to be superior to the method I proposed. In reply I would state that his method is only a very slight modification of that of "cost-plus-a-lump-sum," and has all the serious objections which are inherent to that method. However, I readily concede that it is the best of all the straight cost-plus methods, although not as good as many of the modified ones. He does not have anything in his form of contract that will prevent the total cost from running to outrageous limits or that will discourage the workmen from "soldiering" on the job. All that the contractor loses by loafing is his personal time and the use of his plant, which might be employed profitably on other work.

Mr. Hailey makes a point of the trouble involved in estimating the quantities of all the materials needed in order to arrive at a "proper lump sum." Such estimating is one of the duties of the engineer who prepares the plans and specifications; and it is never omitted in first-class engineering. Moreover, the contractor is very seldom paid by an unmodified lump-sum; for the said sum [illegible] nearly always adjusted to suit the final quantities—at any rate it has to be in the method which I proposed.

In spite of Mr Hailey's seven claims for the "cost-plus-unit-profit" method, it does not protect the owner. It does protect the contractor, and it reduces the labor of doing the engineering work—but is the owner interested very greatly in limiting the amount of work which his engineer has to do when such limitation is obtained by failing to safeguard the said owner against an unlimited cost? There is truth in Mr Hailey's seventh claim, viz., that his method is adaptable to war-work, but we are now dealing with peace conditions. Surely all sensible men will agree that the extravagant methods employed in war times are not applicable to work in peace times! Again, the letting of work without full preliminary investigation should be discouraged as much as possible; for it adds to the cost of the construction, and, instead of saving time, it nearly always increases the amount required for completion.

Mr. Hailey's modification of the ordinary "cost-plus" method tends to cut out competition, and favors a selected few of the larger and more experienced contractors, rendering it difficult for the smaller and less experienced ones to secure any work except through some other method of letting. Again, his claim that it requires the minimum of labor in cost keeping is incorrect, because it would necessitate just as full and accurate a record of all costs as would any of the other "cost-plus" methods or modifications thereof, or as would my proposed ideal method.

Mr. Hailey states, "It would be well worth while for the American Society of Civil Engineers to go into the question of contract forms with the view of using its prestige to urge the universal adoption of a standard form, keeping in mind its adaptability to all kinds of work, including emergency construction, for that was the cause of so much recent public work being let on the cost-plus-percentage basis." Mr. Hailey is perfectly right in this statement, but on Sept. 3 the A. S. C. E. at its regular meeting turned down a motion to that effect proposed by Dr. T. Kennard Thomson and seconded by myself. As usual, when there arises an opportunity to do something worth while instead of merely talking about it, the society "passed the buck." Unfortunately, this "passing of the buck" is very common amongst technical organizations; and it constitutes one of the principal reasons why the engineering profession has failed to attain to its possibilities. To do away with it and its baneful influence was one of the principal objects in the long-continued endeavor to establish an American Academy of Engineers—a movement which is by no means dead but merely lying dormant awaiting the psychological time for its renewal.

J. A. L. WADDELL
Kansas City, Mo. Consulting Engineer

"Users Tax" for Road Maintenance

To the Editor: In your issue of Aug. 6, 1919, appears a letter from Mr. C. A. Mullen, Director of Paving Department of the Milton Hersey Co., suggesting that a tax be placed on gasoline used by motor vehicles to compensate for the "destructive use of the road by the owner of the vehicle." This matter was discussed by the writer in an article appearing in your April 2 issue, p. 331.

There would be difficulty in applying the gasoline tax due to the multiplicity of uses of gasoline, and the fact that other fuels, such as kerosene and alcohol, may be used. The writer proposed a "users' tax" and suggested a tentative formula.

It would be necessary to provide each vehicle with a speedometer under seal, which would be set and read at certain intervals by the proper officials. It is customary to pay for use of water, electricity and gas as measured by meter (under seal) and read periodically. In addition it is customary to charge a minimum or fixed charge to cover necessary cost of inspection, etc. This charge corresponds to the registration fee, which was discussed in the writer's article and which fee is now in general use. All utilities of public character should charge equitably and this can only be done where use of such utility or its product, is measured.

This idea of charging in proportion to use is being applied to street railway service by the so-called "zoning" system. There seems to be no valid reason why the Government, which furnishes and maintains the road for vehicle use, should not charge for the service it offers. The funds so derived would be used for maintenance and partly to pay for new construction or reconstruction.

With reference to the formula (Formula [illegible] p. 331, April 2, 1919), it should be noted that an attempt was made to give weight to the destructive character of the power and loading of the vehicle. In fixing the exemption of 5,000 miles per year it appears that only the regular or steady users of the road would be affected. They should view the tax as fully warranted since the upkeep and extension of the road is literally the "foundation" of their business. The effect of speed is a matter of regulation and of course is not represented in the formula. The writer does not claim the formula to be correct or of universal application; but it is representative of the idea that the user should pay in proportion to his use and abuse (?) of the road. A more satisfactory formula for a given locality can be derived by considering the ratios of wear, cost of administration, amount of funds needed, etc.

H. J. FIXMER,
Paving Engineer Board of Local Improvements.
Chicago, Ill.

Policy of New Transportation Bureau of Federal Highway Council.—The following policy has been adopted as representing the aims and objects of the recently established transportation bureau of the Federal Highway Council:

To assist in co-ordinating the highways with the other transportation agencies of the country; to encourage the development of highways that will advance the economic life of the nation; stimulate their use in such a manner as to facilitate and cheapen the transportation of food, raw materials and finished products, and to co-operate with Government agencies, both state and national, to the end that our highways may be of maximum service in the transportation system of the country. In announcing this platform it will be the aim of the Transportation Bureau to seek: To recognize the problems of the road builder. To realize the needs of the road user. To visualize future highway transport requirements. To co-operate with the railroads and waterways to the end that the public may have in full that form of transportation which is most efficient, economical and practical. To study the problems attending the entrance of the motor truck into our commercial life in order that we may assist the industry which is industrially great and financially strong, in its efforts to be economically right. To promote uniform legislation and encourage every movement for the safety of life and limb on the highway. To encourage the establishment of motor express lines, where such lines will insure a fair return to the investor and serve a useful purpose in the community. To gather such information and statistics as will be of value to those interested in determining the economic field for highway transport, and act as a clearing house for the dissemination of the same.

Advantages of Rural Motor Express.—The more important advantages resulting from a wide extension of rural motor express routes are summarized as follows in a recent report of the Reconstruction Commission of the Highways Transport Committee of New York:

1. Giving a market outlet to food supplies hitherto unavailable because of the distance between producer and the market and lack of transportation. 2. Transportation of produce to the consumer more quickly and in better condition than is possible under present methods. 3. Maintaining of men and horses on the farms who now spend a great part of their time driving to market. 4. Elimination of unnecessary handling and special packing of produce involved in shipping by rail. 5. Establishment of more direct connections between farmer and market. 6. Encouragement of diversity in farming, as a result of widening the marketing areas. 7. Substituting for the disinterested impersonality and limited liability of railroad shipping on short hauls, an agency that personally collects and delivers produce, performing marketing as well as transportation functions. 8. Serving as a feeder to the railroads and water transportation lines.

Expenditures for Federal Aid Road Construction.—There had been expended from the Federal Aid funds in the hands of the Government up to July, 1919, $3,573,937; there was available on that date $80,000,000, which would make an unexpended balance of $76,426,062. There will be an additional amount available for the fiscal year ending July, 1920, of $95,000,000, making a total of $171,426,062 available for road work this season and the early part of next year. At the present rate of construction the larger part of this amount will be unexpended at the end of the fiscal year 1920.

The Economic Limit to Motor Truck Weights

(A continuation of an article with the above title published in Engineering and Contracting, January 1, 1919.)

By ROBERT C. BARNETT.

Economic Engineer, Kansas City, Mo.

In the previous article attention was called to the four steps involved in attacking the problem. The first two of these steps were discussed and the conclusion was reached that, in order to arrive at a logical basis for determining the economic limit it would be necessary to know the quantitative relation between the wheel load and each one of the twenty-one items making up the cost of transportation. The determination of these twenty-one relations constitutes the third step in the program for procedure.

The purpose of this article is to set forth such data as the writer now possesses, bearing upon these sought for relations, and to derive therefrom definite expressions for the functions. There is yet needed a large amount of experimental work, observation, and compilation of existing information before the final setting can be given these functions. However, this discussion will serve to emphasize our present deficiencies and to better crystalize our ideas.

For the convenience of the reader, these sought for relations are again tabulated as follows:

	Symbol
I. ANNUAL COST OF ROADBED:	C_r
1. Relation between wheel load and interest charge on cost of paving, bridges and culverts	I_r
2. Annual maintenance charge on same	M_r
3. Annual cost of administration	A_r
4. Annual cost of amortization	B_r
II ANNUAL COST OF POWER:	C_p
1. Interest charge on power plant	I_p
2. License and taxes	L_p
3. Insurance	E_p
4. Administration	A_p
5. Cost of garaging per annum	J_p
6. Cost of gasoline per annum	G
7. Cost of oil, grease and waste per annum	Q
8. Annual salaries paid drivers and helpers	S_p
9. Annual cost of maintenance of power plant	M_p
10. Annual cost of amortization of power plant	B_p
III. ANNUAL COST OF VEHICLES:	C_p
1. Interest charge	I_v
2. License and taxes	L_v
3. Insurance	E_v
4. Administration	A_v
5. Cost of garaging per annum	J_v
6. Cost of maintenance	M_v
7. Cost of amortization	B_v

The phase of the problem now to be presented is, in general terms, that of finding for a specific roadway and a given annual ton-mileage a set of trucks, each of a certain capacity and therefore, wheel load, such that a minimum unit cost of transportation will result. For this purpose, it will be convenient to consider that the annual cost of vehicles is merged with the annual cost of power; for in this case the vehicle and power plant form a unit. For convenience, this combined cost will be termed Annual Cost of Operation.

A concise statement of the problem then becomes:

$$\underset{\text{(To be made a minimum)}}{\text{Cost per ton-mile}} = \frac{\text{Total Annual Cost}}{\text{Annual Ton-mileage}} = \frac{C_a}{mT_a}$$

Where T_a = annual tonnage transported, a constant
m = weighted average of mileage per ton,
and $C_a = C_r + C_p$, a variable depending on the capacity of the truck.

Therefore, since the annual ton-mileage is to be a fixed amount, the lowest unit cost must be obtained by making C_a a minimum through the proper selection of the size of truck. In order to do this, it is necessary to know how C_r and C_p are related to truck capacity.

But as $C_r = I_r + M_r + A_r + B_r$, and $C_p = I_p + L_p + E_p + A_p + J_p + G + Q + S_p + M_p + B_p$, we must determine how each one of these fourteen factors is related to truck capacity. To facilitate the subsequent discussion of these functions, our system of nomenclature will be extended to include the following:

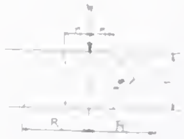
Let $a = 586\frac{2}{3}\, l\, w\, c\, b$, a constant.
b = constant in equation for thickness of pavement.
c = constant in equation for thickness of pavement.
d = thickness of pavement in inches.
e = constant in equation for cost of truck.
f = constant in equation for amortization of roadway.
f' = constant in equation for amortization of equipment.
g = constant in equation for cost of administration of roadway.
h = time in hours required to make one round trip.
i = rate of interest expressed as a decimal.
j = constant in tax equation.
k = constant in equation for cost of maintenance of pavement.
l = length of roadway in miles.
m = weighted average of mileage per ton.
n = constant in insurance equation.
p = constant in administration equation.
p_c = cost of pavement per square yard.
q = constant in equation for cost of garaging.
r = constant in equation for cost of gasoline.
s = salary per annum paid one driver.
t = number of round trips per annum made by one truck.
u = constant in equation for cost of oil, grease and waste.
v = constant in equation for cost of maintenance and equipment.
w = width of roadway in feet.
x = life of pavement in years.
y = life of truck in years.
z = unit tractive resistance stated as a decimal of a pound per pound of load.
A = amount of abrasion or wear due to one passage of the load stated as a decimal part of the original pavement
B = constant in equation for wear of pavement.
C_t = cost of a truck in dollars.
D = distance in miles which a truck will travel in one year.
E_c = cost of entire equipment.
G' = cost of gasoline for one truck per annum.
H = total working hours in the year.
K = capacity of one truck in tons.
N = number of motor trucks forming the equipment.
P = number of wheels passing over pavement per annum.
P_c = cost of entire pavement.
Q = annual cost of oil, grease and waste.
R = number of repetitions of wheel load.
S = speed of truck in miles per hour.
S_p = surface of pavement in square yards.
U = annual wear of pavement due to wheel load, stated as a decimal part of original pavement.
V = work done per annum by one truck measured in foot-pounds.
W = wheel load in pounds.

There are five fundamental relations which govern the forms of the functions sought. These will be considered briefly before proceeding with the main discussion. These five relations concern:

1. Thickness of pavement and weight of truck.
2. Wear on pavement and weight of truck.
3. Weight of truck and its capacity.
4. Cost of truck and its capacity.
5. Number of trucks required and capacity.

The accompanying diagrams show graphically the forms of some of these functions as at present determined by the writer. The basic information for such determination is now set forth as briefly as is consistent with the purpose of this paper. A more extended discussion of them may be undertaken later.

Relation between thickness of pavement and weight of truck.—There are two cases to be considered: Case 1: Pavement composed of aggregate and binder, in which the chief resistance to displacement is due to friction of the particles upon each other, rather than to tensile stresses set up by deformation. Gravel, waterbound and bituminous macadam pavements are examples of this class. Owing to the deformation of the rubber tire under its load, the wheel load may be considered as being distributed over a small approximately circular area at the top surface of the pavement. The friction among the particles and the cementing effect of the binder causes a distribution of the load over an increasing area as it is transferred downward to the subgrade. Experiments indicate that the greatest intensity of pressure is directly beneath the load and that this intensity diminishes for regions removed from the point of application of the load. As yet, the law of variation is not completely determined. For the present, the intensity of pressure will be considered uniform over the load area at the base of the pavement. The dimensions of this area will be based on the following consideration:



Let r_1 = radius of upper pressure area
R = radius of lower load area
d = thickness of pavement
α = angle of distribution of load
W = wheel load

Then $R = r_1 + d \tan\alpha$

Load area at base of pavement $= \pi R^2 = \pi(r_1 + d\tan\alpha)^2$

The intensity of pressure must not exceed the allowable bearing capacity of the subgrade material.

Let this be represented by P_a, then

$$P_a = \frac{\text{Load}}{\pi R^2} = \frac{W}{\pi(r_1 + d\tan\alpha)^2}$$

Solving for d, we have:

$$d = \cot\alpha\sqrt{\frac{W}{\pi P_a}} - r_1\cot\alpha$$

If α be taken at 45°, as is frequently done, then

$$d = \sqrt{\frac{W}{\pi P_a}} - r_1$$

Case II: Slab type of pavement: In this type of pavement, there is sufficient tensile strength of the material to resist bending, hence, the tendency will be to distribute the load over a larger area than in the first case. This bending of the slab will give rise to a varying intensity of pressure, or reaction. This reaction at any point in the loaded area at base of slab will be proportional to the depression of the subgrade at that point. Without attempting at this time, a complete analysis of the system of actions and reactions set up, we may note the few obvious and elementary principles involved. The total reaction must of course equal the wheel load. The greatest deflection of the slab will be under the load and must not be sufficient to overstress the material forming the slab. The resistance offered by the slab to bending is proportional to its moment of resistance at any section, which in turn varies as the square of the thickness of the slab. The greater the wheel load, the greater the bending moment and, because the moment of resistance at the critical section must equal the bending moment, the greater must be the thickness of the slab, hence, we draw the conclusion that $M_B = a_1W = M_R = c_1d^2$, or $d^2 = \frac{a_1}{c_1}W$

and
$$d = \sqrt{\frac{a_1}{c_1}W}$$

It may be noted here that the progress report of the special committee of the American Society of Civil Engineers, published in the 1918 Transactions, contains the basis for determining the stresses in an elastic structure supported continuously on an earth subgrade. The equation there given for the curve formed by the depression of the elastic track can be adapted to fit the depression of a slab of road pavement. A discussion of this detail is reserved for a later paper.

The form of this function is very similar to that derived for Case 1 and can be made more so by decreasing the coefficient of $\sqrt{\frac{W}{P_a}}$ and dropping r_1. From this we conclude that for practical purposes $d = \sqrt{\frac{W}{P_a}}$.

As shown by its 1901 report, the Massachusetts Highway Commission adopted the formula $d = \sqrt{\frac{W}{4P}}$

Where d = thickness of pavement in inches
W = wheel load in pounds
P = supporting power of sub-grade in pounds per sq. in.

We will therefore adopt for the present the formula

$$d = b\sqrt{W}$$

Then b would depend upon bearing capacity of soil. No provision is yet made for impact which would bear some relation to speed of truck.

Relation between wear of pavement and weight of truck.—The wheel load in passing over the pavement causes an abrasion of the top surface or a displacement of its particles and, through the horizontal shear set up by the reaction of the tire against the pavement, a tendency to displace the entire aggregate along horizontal planes. While there is a woeful lack of specific and precise data upon the amount of this wear for different wheel loads and different road surfaces, yet, observation will bear out the following conclusion:

That the rate of wear at any instant is a function of:

1. Wheel load.
2. Width of tire.
3. Number of repetitions of loading which have preceded the one under observation.
4. Type of pavement.
5. Type of tire.
6. Resiliency of tire and buffer springs.
7. Speed at which the load moves across the pavement.
8. Total wear of pavement up to the instant under consideration.

For the present, we are concerned only with the wheel load, the number of repetitions and the speed of the vehicle, so the other factors will be considered as remaining constant. If the surface of the road is properly maintained so that no cumulative deterioration results, the rate of wear, or the amount of abrasion, for one passage of the load varies as the wheel load and as the square of its velocity. Letting

A = amount of wear, or abrasion, caused by one passage of the load to be measured as a percentage of original pavement.
W = wheel load in pounds.
S = speed of passing load in miles per hour.
R = number of repetitions of loading per annum.
U = amount of annual wear measured in percentage of original pavement.
B = constant depending upon the type of pavement and kind of tires.

we have

$$A = BWS^2$$

and

$$U = BRWS^2$$

The repetitions per annum will depend upon the number of trucks N and the average number of round trips t per truck per annum, or

$$R = 2Nt.$$

It is later shown that $Nt = \frac{T_a}{K}$ so $R = \frac{2T_a}{K}$, therefore

$$U = \frac{2BT_a}{K} WS^2$$ which is the relation sought.

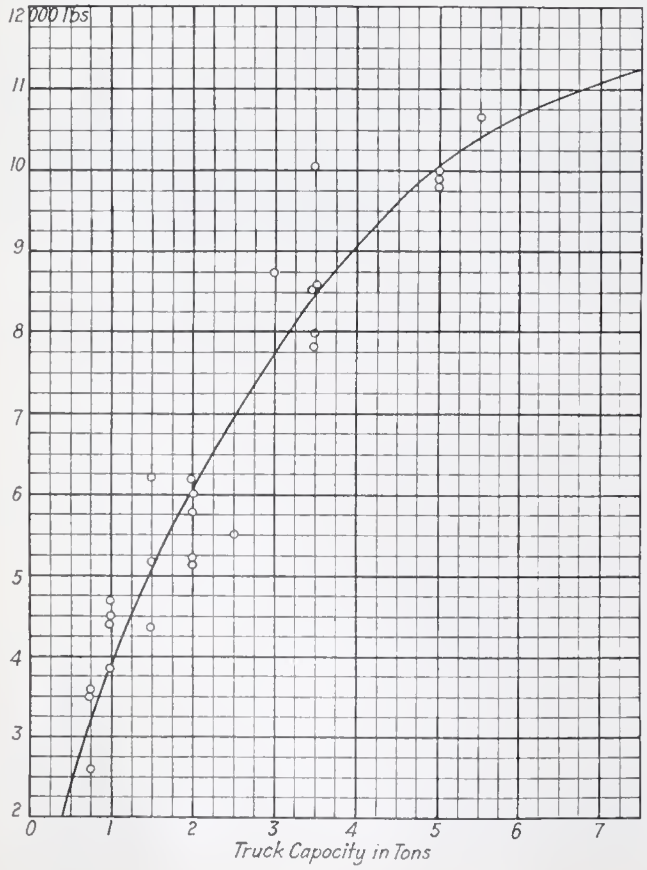


Fig. 1—Weight of Truck (Chassis and Body).

Relation between weight of truck and its capacity.—Graphs plotted from manufacturers' data show discordant results. This is to be expected, as there can be no rigid relation between weight and load capacity unless all designs confrom to one set of standard specifications. Therefore, there is no need for attempting great refinement in expressing the general truth, conveyed by Fig. 1, that the larger capacity trucks have less weight per unit of capacity than do the smaller trucks. The full line shown in Fig. 1 represents a probable average weight for different sizes of trucks. As this curve does not conform to any simple equation, values will be taken direct from the diagram.

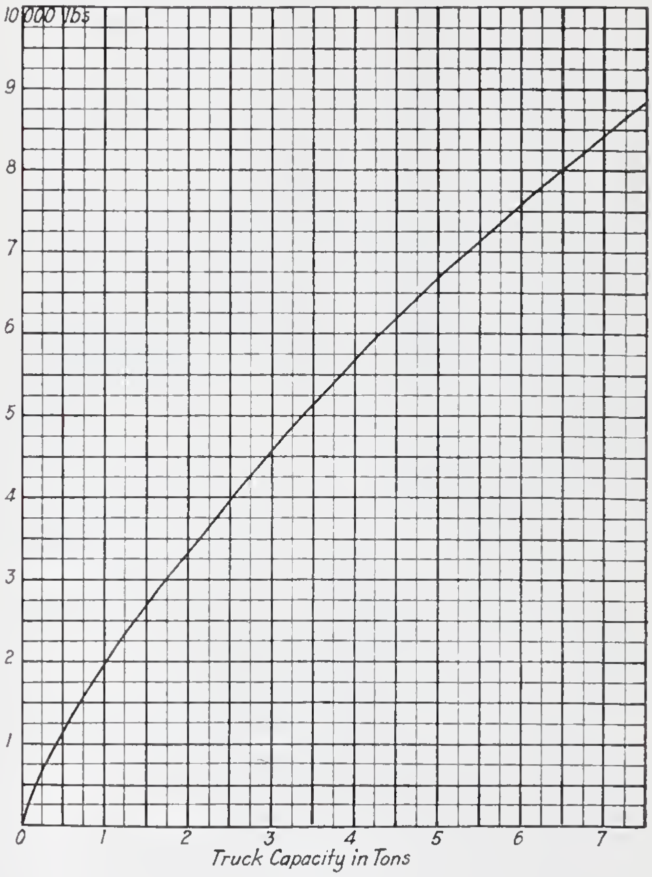


Fig. 2—Wheel Load
($W = 2000\ K^{3/4}$)

The total weight carried by the four wheels will be the weight of the truck, plus its capacity load. Two-thirds of this total load is usually carried by the rear axle, or one-third by each driver. The following table shows these several functions:

K. Tons.	Weight of Truck. Lbs.	Gross Load = K + Wt. of Truck. Lbs.	$W = \frac{\text{Gross Load}}{3}$ Lbs.
½	2,400	3,400	1,133
1	3,850	5,850	1,950
2	6,050	10,050	3,350
3	7,750	13,750	4,583
4	9,075	17,075	5,692
5	10,100	20,100	6,700
6	10,700	22,700	7,567
7	11,150	25,150	8,383

Fig. 2 shows W as a function of K. It is closely approximated by the equation $W = 2000\ K^{3/4}$.

Relation Between Cost of Truck and Its Capacity.—The average price of motor trucks for 1918-1919 as published by the Commercial Vehicle, are set forth in the accompanying table:

Capacity.	Cost.	Capacity.	Cost.
½ ton	$ 835.00	3 tons	$3,688.00
¾ ton	934.00	3½ tons	3,905.00
1 ton	1,391.00	4 tons	4,178.00
1½ ton	1,815.00	5 tons	4,849.00
2 ton	2,758.00	6 tons	5,238.00
2½ ton	2,956.00	7 tons	5,600.00

Fig. 3 shows in graphical form this relation, and also a curve approximating this function, which has for its equation, $C_t = 1,600\ K^{2/3}$.

Relation Between Number of Trucks Required and Truck Capacity.—To transport over this road, l miles long, the given annual tonnage, T_a, a certain equipment is needed. This equipment will consist of N trucks, each having a load capacity of K tons. As each truck makes t round trips in the year's time, the total annual tonnage moved will be given by the equation, $T_a = KNt$. However, t is a function of the speed of the truck, as may be seen from the following:

Let S = Speed in miles per hour.
h = Time in hours required for one round trip.
t = Number of round trips per truck per annum.
H = Total number of working hours per annum.

Then the time required for one round trip is

$$h = \frac{2l}{S}$$

The number of round trips per annum which one truck can make is

$$t = \frac{H}{h} = \frac{HS}{2l}$$

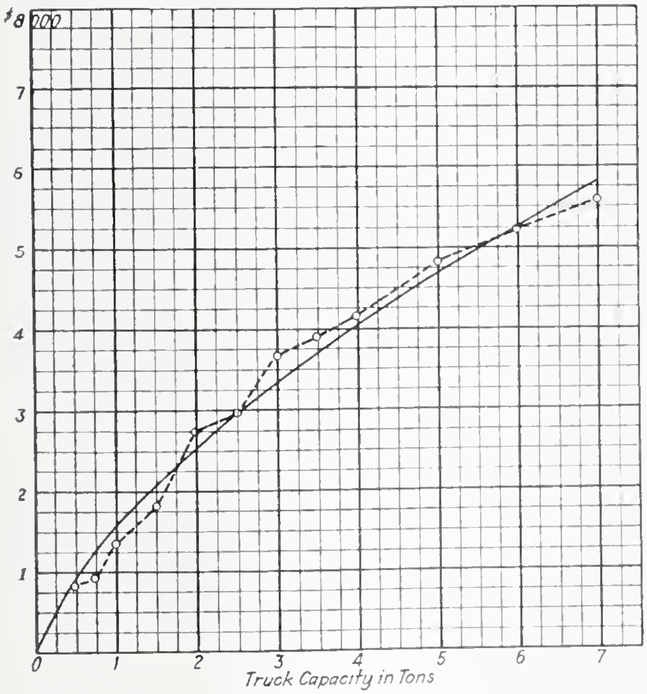


Fig. 3—Cost of Truck
($C_t = 1600\ K^{2/3}$)

Substituting this value for t in the foregoing equation for tonnage, we have,

$$T_a = \frac{KNHS}{2l}$$

Solving for N, in order to obtain the equipment needed, we have,

$$N = \frac{2T_a l}{KHS}$$

Having derived such provisional expressions for these fundamental relations, we will next pass to the consideration of the special relations which we are seeking to establish for the fourteen cost items in terms of wheel load.

1. **Annual Cost of Roadbed** $= C_r$.—Under this heading we have, first, interest on cost of roadbed $= I_r$. As the cost of pavement generally comprises the major part of the cost of roadbed, the cost for bridges and culverts will be considered as merged with the cost of pavement. It is readily seen that the total cost of pavement for a roadway l miles long and w feet wide is equal to the product of its surface by the unit price, or

$$P_c = S_p p_c$$

but

$$S_p = \frac{5280\ lw}{9} \text{ square yards.}$$

and

$$S_p p_c = 586\tfrac{2}{3} lwp_c.$$

However, the unit cost, p_c, varies as the thickness of the pavement, and the thickness of the pavement varies as the square root of the wheel load, or

$$p_c = cd = cb\sqrt{W}$$

Therefore, the total cost of pavement becomes

$$P_c = 586\tfrac{2}{3} lwcb\sqrt{W} = a\sqrt{W}$$

Let i = rate of interest expressed as a decimal

Then $I_r = ia\sqrt{W}$

This is the relation sought.

2. **Cost of Maintenance of Pavement** $= M_r$.—For a pavement of a given type and material, the cost of maintenance due to traffic depends directly upon the amount of wear on its upper surface. As has been shown, the wear is a function of the wheel load, the speed and the number of repetitions of the loading, or

$$U = 2\frac{BT_a WS^2}{K}$$ Expressed as a decimal part of original pavement. Then $M_r = kU$ in which $k = a\sqrt{W}$, the original cost of the pavement. Therefore $M_r = \frac{2aBT_aW^{3/2}S^2}{K}$

which is the relation sought.

3. **Cost of Administration** $= A_r$.—To carry on the work of maintaining a roadway, there is needed an organization with an administrative head and headquarters. The more extensive the maintenance, the more time required, or the larger the organization must be to handle it. The larger the organization, or the more active its efforts, the more demands made upon the administrative head. Hence, it may be concluded that the cost of administration bears a direct relation to the cost of maintenance, or

$$A_r = gM_r \quad \text{or}$$

$$A_r = \frac{2agBT_aW^{3/2}S^2}{K}$$

4. **Cost of Amortization** $= B_r$.—To replace that part of the pavement which wears out, or deteriorates, in spite of annual maintenance; it will be necessary to establish a sinking fund. The annual installment paid to this sinking fund represents the cost of amortization.

$$\text{Annual Installment} = \frac{p_c i}{[(1+i)^x - 1]}$$

While it is customary to express the life of the pavement in years, there is some relation between that life and the amount of traffic carried, or x is a function of wheel load and number of repetitions. With a properly designed pavement and regular maintenance x should be constant, or nearly so, for any particular roadway. Hence, the cost of amortization depends on p_c or

$$B_r = fp_c \qquad \text{where}$$

$$f = \frac{i}{[(1+i)^x - 1]}$$

Then

$$p_c = a\sqrt{W}$$

therefore,

$$B_r = af\sqrt{W}$$

Summary—Annual Cost of Roadbed $= C_r$.—This is the sum of the four preceding cost items, or

$$C_r = I_r + M_r + A_r + B_r$$

but factor

1. $I_r = ia\sqrt{W}$
2. $M_r = \frac{2aBT_aW^{3/2}S^2}{K}$
3. $A_r = \frac{2gaBT_aW^{3/2}S^2}{K}$
4. $B_r = af\sqrt{W}$

Therefore,

$$C_r = a(i+f)\sqrt{W} + aBT_a(1+g)\frac{W^{3/2}S^2}{K}$$

Annual Cost of Operation $= C_o$.—Under this heading we have,

First: Interest on cost of equipment $= I_o$.

This equipment will consist of N trucks, each having a carrying capacity of K tons. The cost of a truck is given by the equation,

$$C_t = 1600\ K^{2/3}$$

For N trucks, the total first cost will be

$$E_c = NC_t = 1600NK^{2/3}$$

It has been shown that

$$N = \frac{2T_a l}{KHS}$$

Substituting this value for N in the above equation for cost of equipment, we now have that cost stated in terms of truck capacity, thus,

$$E_c = \frac{3200\ T_a l}{HSK^{1/3}}$$

Second: Cost of license and taxes = L_p.

The cost of a license to operate varies in different localities and is frequently based upon the size of the motor. As a matter of justice, the cost of a license should bear some relation to the wear on the pavement caused by the trucks. It has been seen that this wear is

$$U = \frac{2\ BT_aWS^2}{K}$$

In a properly adjusted system, the license fees should equal the cost of maintaining the pavement. Then the total annual cost for license is given by the equation

$$L^1 = M_r \quad \text{or}$$

$$L^1 = \frac{2aBT_aW^{3/2}S^2}{K}$$

Taxes are based on cost of equipment and will be proportional thereto, or

$$\text{Taxes} = jE_c = \frac{3200jT_al}{HSK^{1/3}}$$

then,

$$L_p = \frac{2aBT_aW^{3/2}S^2}{K} + \frac{3200jT_al}{HSK^{1/3}}$$

which is the function sought.

Third: Cost of insurance = E_p.

This factor will vary as the cost of equipment, or

$$E_p = nE_c$$

but

$$E_c = \frac{3200\ nT_al}{HSK^{1/3}}$$

therefore,

$$E_p = \frac{3200\ nT_al}{HSK^{1/3}}$$

Fourth: Cost of administration = A_p.

This factor will vary as the number of trucks, or

$$A_p = pN$$

where

$$N = \frac{2T_al}{HSK}$$

therefore

$$A_p = \frac{2pT_al}{HSK}$$

Fifth: Cost of garaging = J_p.

This factor will also vary as the number of trucks, hence,

$$J_1 = qN = \frac{2qT_al}{KHS}$$

where q = annual cost for one truck.

Sixth: Cost of gasoline per annum.

For the individual truck, the gasoline consumed would vary as the mechanical work done per annum; that is, as the gross load transported per trip and as the distance traveled over in the year's time, or

$$G^1 = 3r\ WD$$

in which

r = Constant

W = Wheel load and 3W = total gross load

D = Distance traveled, or the number of round trips times length l.

or

$$D = tl$$

but

$$t = \frac{HS}{2l} \text{ so } D = \frac{HS}{2}$$

Therefore,

$$G^1 = \frac{r\ WHS}{2}$$

The gasoline cost for the entire equipment of N trucks would be

$$G = NG^1 = \frac{rT_alW}{K}$$

Seventh: Cost of oil, grease and waste = Q.

Observation shows that this factor varies directly as the amount of gasoline used. Hence,

$$Q = uG = \frac{urT_a\ lW}{K}$$

Eighth: Drivers' salary = S_p.

The total salary paid to drivers will be proportional to the number of trucks, or

$$S_p = sN = \frac{2sT_al}{HSK}$$

where s is annual salary paid one driver.

Ninth: Maintenance of equipment = M_p.

The annual cost of maintaining a truck will bear a direct relation to the amount of mechanical work which it performs during the year.

Making t round trips per annum over a road l miles long, the truck will travel tl miles against a certain resistance, depending upon the unit tractive resistance z of the road surface and the total load, 3W.

Letting V = work done per annum by one truck in foot pounds, we have

$$V = 5{,}280\ (tl)3zW = 15{,}840\ tlzW \quad \text{foot-pounds}$$

but

$$t = \frac{HS}{2l}$$

therefore

$$V = 15{,}840\ \frac{(HS)}{2}\ zW = 7290\ WHS$$

The cost of maintaining one truck then becomes

$$M^1_p = vV \text{ where } v = \text{a constant.}$$

The cost of maintaining N trucks would be

$$M_p = vNV$$

but

$$N = \frac{2T_al}{KHS}$$

Substituting values for N and V, we have

$$M_p = \frac{15{,}840\ vlzT_aW}{K}$$

Tenth: Cost of Amortization of Equipment = B_p.

This factor is a function similar to that of roadbed amortization. The amount to be replaced is E_c. The annual installment required to produce this amount in y years is given by the formula

$$B_p = \frac{E_ci}{[(1+i)^y - 1]}$$

but

$$\frac{i}{[(1+i)^y - 1]} \text{ is a constant, call this } f^1$$

then

$$B_p = f^1\ E_c$$

in which

$$E_c = \frac{3200\ T_al}{HSK^{1/3}}$$

therefore

$$B_p = \frac{3200\ f^1T_al}{HSK^{1/3}}$$

Summary—Annual Cost of Operation = C_p.

The annual cost of operation is the sum of the preceding ten factors, or

$$C_p = I_p + L_p + E_p + A_p + J_p + G + Q + S_p + M_p + B_p$$

Factor

1. $$I_p = \frac{3200\,iT_al}{HSK^{1/3}}$$

2. $$L_p = \frac{2aBT_aW^{2/3}S^2}{K} + \frac{3200JT_al}{HSK^{1/3}}$$

3. $$E_p = \frac{3200nT_al}{HSK^{1/3}}$$

4. $$A_p = \frac{2pT_al}{HSK}$$

5. $$J_p = \frac{2qT_al}{HSK}$$

6. $$G = \frac{rT_alW}{K}$$

7. $$Q = \frac{urT_alw}{K}$$

8. $$S_p = \frac{2sT_al}{HSK}$$

9. $$M_p = \frac{15840\,vlzT_aW}{K}$$

10. $$B_p = \frac{3200\,f'T_al}{HSK^{1/3}}$$

Collecting and combining like terms we have

$$C = \frac{3200\,T_al}{HSK^{1/3}}(i + j + n + f') + \frac{2T_al}{HSK}(p + q + s) + \frac{T_alWr}{K}(1 + u) + \frac{2T_aW}{K}(aBW^{1/3}S^2 + 7920\,vlz)$$

We may now write an expression for the total annual cost by adding the annual cost of roadbed to this annual cost of operation, that is

$$C_a = C_r + C_p$$

or

$$C_a = a(i + f)\sqrt{W} + aBT_a(1 + g)\frac{W^{2/3}S^2}{K} + \frac{3200\,T_al}{HSK^{1/3}}(i + j + n + f') + \frac{2T_al}{HSK}(p + q + s) + \frac{T_alWr}{K}(1 + u) + \frac{2T_aW}{K}(aBW^{1/3}S + 7920\,vlz)$$

This equation contains three inter-related variables, W, S, and K. It has been shown that the relation between W and K may be approximated by the equation

$$W = 2000\,K^{3/4}$$

it now remains to determine the relation between S and K. As there is no rigid physical dependence of S on K within the limits of practice, the criterion for establishing the connection between these two is an economic one. We then must seek that relation which will permit of the greatest economy. For this purpose the first differential coefficient of C_a with respect to S may be placed equal to zero and an expression will be obtained giving S in terms of K and W and the various constants, thus

$$\frac{dC_a}{dS} = \frac{2aBT_a(1 + g)W^{2/3}S}{K} + \left(-\frac{3200T_al}{HK^{1/3}S^2}\right)(i + j + n + f') + \left(\frac{-2T_al}{HK}S^{-2}\right)(p + q + s) + \frac{4T_aW^{1/3}aBS}{K} = 0$$

Solving for S, we have

$$S = \sqrt[3]{\frac{\frac{1600l}{H}\left\{(i+j+n+f')K^{2/3} + \frac{(p+q+s)}{1600}\right\}}{aPW^{2/3}(3 + g)}}$$

As $\frac{d^2C}{dS^2}$ is positive, this value for S makes C a minimum.

It has been seen that

$$W = 2000K^{3/4}$$

Substituting under the radical, we have

$$S = \sqrt[3]{\frac{\frac{1600l}{H}\left\{(i+j+n+f')K^{2/3} + \frac{(p+q+s)}{1600}\right\}}{89443\,aB(3+g)K}}$$

This expression for the general value of S which satisfies the criterion for maximum economy is too cumbersome to substitute directly in the equation for total annual cost. It is seen that the critical speed is different for different roadways. In order then, to follow the investigation further, it will be necessary to select some specific roadway and determine S for that special case. For this purpose we will assume a hard surface road 20 miles long and 18 ft. wide, subjected to a traffic of motor trucks hauling 300,000 tons per annum. We seek to determine the critical speed and the size of truck which will produce the least annual cost. The constants in the speed equation are taken as follows:

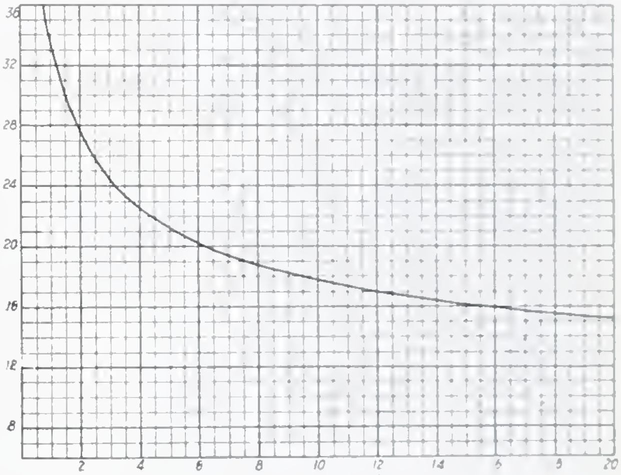


Fig. 4—Economic Speed

$$\left(S = \frac{28.1\sqrt[3]{0.43\,K^{2/3} + 1.39}}{K^{1/3}}\right)$$

l = 20 miles
i = .06
j = .02
n = .03
f' = .32
p = 600
q = 120
s = 1500
H = 3,000 hours
A = 751.6 l = 7032
$B = \frac{2.153}{10^{13}}$
g = .05
f = .02743
T_a = 300,000 tons
$r = \frac{85}{10^{7}}$
$u = \frac{.2}{578}$
$v = \frac{[illegible]}{10}$
z = .014

Substituting these values in the expression for S, we have

$$S = \sqrt[3]{\frac{\left(\frac{1600 \times 20}{3000}\right)\left\{(.06 + .02 + .03 + .32)K^{2/3} + \frac{(600 + 120 + 1500)}{1600}\right\}}{89443 \times 7032 \times \frac{2.5}{10^{13}}(3 + .05)K}}$$

This now reduces to

$$S = \frac{28.1\sqrt[3]{0.43K^{2/3} + 1.39}}{K}$$

The accompanying table shows values for S corresponding to the different values for K, and also the simultaneous value for W computed by the formula W = 2000K

The form of this function is shown in Fig. 4

TABLE I

K	W	S	K	W	S
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Reverting now to the general equation for total annual cost we may, by substituting values for the constants and simultaneous values for K, W, and S, next compute the annual cost of transportation for the assumed case for the different sizes of trucks and thereby find the minimum cost.

The equation takes for its final form,

$$C_a = 27368K^{7/8} + 48.6K^{1/8}S^2 + \frac{2,752,000}{SK^{1/3}} + \frac{8,880,000}{SK}$$
$$+ \frac{122,400}{K^{1/4}} \quad (.0447K^{3/8}S^2 + 77)\frac{2000}{K^{1/4}}$$

The following table shows values for C_a conforming to the different sizes of trucks, while Fig. 5 presents the same information in graphical form.

TABLE II.

K	C	K	C
1	$805,286	9	$463,832
2	630,595	10	462,080
3	559,691	12	460,685
4	522,377	13	460,658
5	501,018	14	461,209
6	485,077	15	461,799
7	476,600	20	474,214
8	468,715		

It is seen that, for the assumed conditions, the minimum cost is obtained by using 13-ton capacity trucks and that the economic speed is 16.7 miles per hour. There is a considerable range over which the annual cost changes but slightly. The minimum total annual cost, as shown by the table, for transporting 300,000 tons an average distance of twenty miles, or in other words, of producing 6,000,000 ton-miles of transportation, is in round numbers $461,000. The unit cost then becomes 7.68 ct. per ton-mile. The number of trucks required to transport the assumed tonnage would be 18. The wheel load would be 13,600 lbs., which would require a pavement of equal strength and resistance to abrasion as that of a 12-in. concrete slab resting on good subgrade.

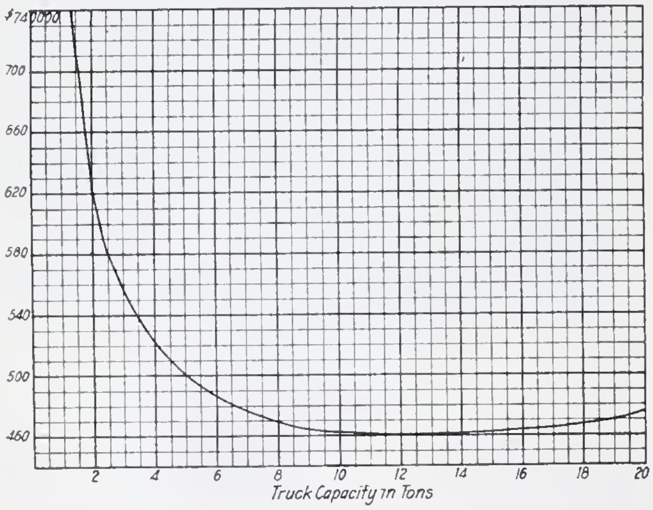


Fig. 5—Annual Cost of Transportation

$$(C_a = 27368\ K^{7/8} + 48.6\ K^{1/8}\ S^2 + \frac{2,752,000}{SK^{1/3}} + \frac{8,880,000}{SK}$$
$$+ \frac{122,400}{K^{1/4}} + (.04472\ K^{3/8}\ S^2 + 77)\ \frac{2,000}{K^{1/4}}$$

While these critical values have been determined for a specific case and the conclusions are valid only for that case, yet to the extent that the assumed case is representative of general conditions, will these results have a bearing and general applicability. To determine the range of applicability necessitates a further consideration of the assumed constants and the extent which allowable deviations therefrom will affect the various functions. The consideration of such variations is left for a later discussion.

The third step in the program for procedure as outlined in the previous article in Engineering & Contracting last January is now completed. There yet remains the fourth step of finding the inter-relations among the factors which obtain at the time the minimum cost is attained. This will be discussed in a later article.

State Highway Departments Spend $66,000,000 in 1918.—The total expenditure of state funds by State Highway Departments for road and bridge work in 1918 was $66,351,000. In 1917 the expenditure was $47,291,000. In these two years every state in the Union participated. In 1914 31 state highway departments expended $4,221,000, and in 1904 11 state highway departments spent $2,550,000.

Compact Portable Outfit for Testing Aggregates in the Field

A factor which probably tends more than any other to discourage adequate control testing of highway materials is the time usually required to send samples to a laboratory for test purposes. Even under the most favorable conditions several days may elapse before a report can be secured, during which time the lot of material represented by the sample must be held. Conditions frequently are such that an engineer or inspector must decide at once upon the arrival of a shipment whether to accept or reject it, so that, unless he is provided with equipment for making tests himself, he must base his decision solely on visual inspection.

Although an inspector ordinarily may be able to reject a consignment without question, instances often arise when even the most expert may be in doubt. This is especially true in connection with determinations of the grading or size of aggregates. These materials always are subject to variations in size due to inefficiency in plant screening and other causes and yet may be intended for use in construction requiring uniformly graded aggregates. An examination, of course, may be made in such cases with the ordinary laboratory equipment. Such equipment, however, is bulky and difficult to move from place to place, and therefore is not adapted to field use, so that up to the present time there has been little or no systematic control testing in the field. The obvious solution is to supply a field equipment which will accomplish the same purpose and still be compact, light, and capable of withstanding a certain amount of rough usage. A description of such an outfit which has been developed recently by the Bureau of Public Roads, together with suggested methods for its use, are given by F. H. Jackson, Assistant Testing Engineer U. S. Bureau of Public Roads, in a recent issue of Public Roads.

Description of Apparatus.—The field equipment so far developed consists of the following units:

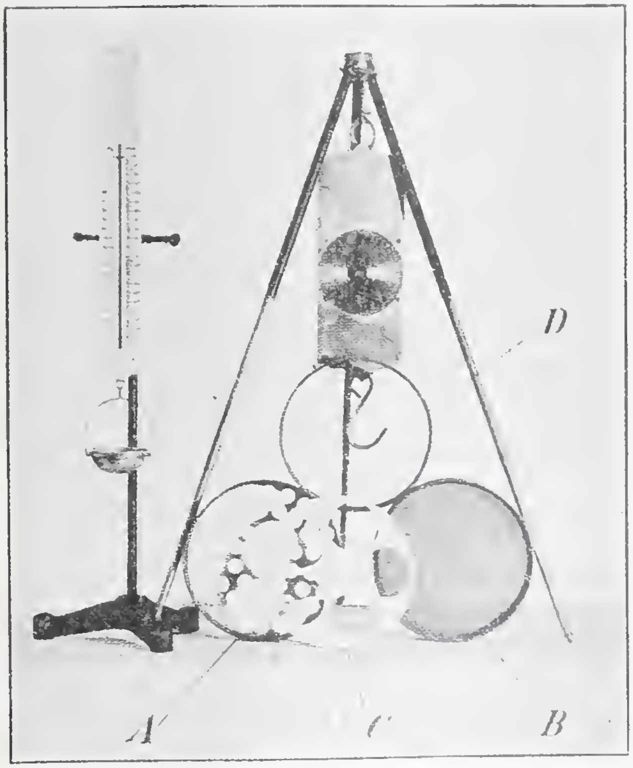
1 set interchangeable stone screens, with screen plates having perforations, 3, 2½, 2, 1½, 1, ¾, ½, and ¼ in. in diameter.
1 set interchangeable sand sieves, of 10, 20, 30, 40, 50, 80, 100, and 200 mesh.
1 circular spring scale having a capacity of 30 lb. and sensitive to 0.1 lb.
1 straight spring balance having a capacity of 200 grams and sensitive to 1 gram.
1 demountable cubic foot box.
1 ordinary camera-folding tripod.
1 250 c. c. graduate.
1 strip of screen wire about 22 in. in length and 5 in. high.
2 canvas bags about 18 by 18 in. in size.

The interchangeable screens used in this equipment were developed in the course of a field study of stone and slag crushing practice which was undertaken recently by the Bureau of Public Roads. They have been used for obtaining mechanical analyses of coarse aggregates, substantially as described below, by engineers of the Bureau throughout two field seasons and have given uniformly satisfactory results. The set consists of a number of perforated screen plates 8 in. in diameter, and two brass rings, one of which is provided with a narrow shoulder on the inside upon which a screen plate may be placed. The two rings are then firmly clamped together so that the screen plate is held rigidly between them. This forms a screen of the same size and shape as the ordinary laboratory type. When not in use all of the plates may be clamped together in the ring so that the whole set takes up no more room than a single laboratory screen.

The circular spring scale is equipped with a loose pointer for obtaining the net weight of the material being examined. It is graduated in 0.1-lb. divisions and one complete revolution of the pointer equals 10 lb. The scale has a total capacity of 30 lb. or 3 revolutions of the pointer.

The sand sieves are of the same general type as the screens, the various sieve plates fitting into the brass rings in the same manner. Thus, a sieve of any desired mesh may be made up by simply inserting the proper sieve plate in the lower ring and clamping it down by means of the upper ring. A soft rubber washer is placed over each sieve plate so that the upper ring will clamp down on it, thus making a dust-proof joint. The straight spring balance is of a special type graduated on one side from 0 to 200 grams by 1 gram divisions and on the other side from 0 to 100 per cent by 1 per cent divisions. It is used in making mechanical analyses of fine aggregates. An aluminum cup is provided large enough to hold a 200-gram sand sample.

In the illustration of this equipment the circular screen scale is supported by the tripod in the way it would be in practice. A screen plate inserted in the lower ring is shown at A, a sieve plate inserted in the ring is shown at B, C shows a screen plate before insertion in the ring, and D the upper, or clamping, ring. The 250 c. c. graduate is the only piece of glass in the outfit and is needed only when it is desired to make volumetric silt determinations. The circular loop of screen wire is used for making apparent specific gravity determinations of coarse aggregates. The object of the strip is to increase the capacity of a screen so that it may be used for weighing samples of sufficient size for this determination. It is rolled in the form of a loop and placed inside of the screen ring which in turn is suspended from the spring scales by means of three light wires.



Apparatus for Making Field Analyses of Aggregates.

The demountable cubic foot box is used for determining weight per cubic foot of crushed slag and other coarse aggregates. It is made of five pieces of light strong wood ¾ in. thick, the bottom 12¾ by 12¾ in., two sides 12 by 12¾ in. and two sides 12 by 12 in. The four sides are first slipped into place and held by notched brass angles. The bottom is then slid into place in the angles provided on three of the sides. Field experience with this measure has suggested that the wooden bottom be protected on the outside by a sheet of thin metal. This would materially increase the life of the apparatus. In making sieve analyses this box is very handy for catching the fines. When collapsed the box consumes little more space than the actual volume of the material. When made of poplar the total weight is 7 lb. Oak, while harder, would increase the weight a pound or so.

The total outfit described above weighs approximately 18 lb. The apparatus making screen and sieve analyses weighs approximately 10 lb. and may be packed in a space measuring 17 by 8 by 6 in.

Suggested Methods for Sampling.—The importance of the proper sampling of materials in connection with the field testing of aggregates can not be over-emphasized. It is the one branch of testing work to which the least attention is paid, and yet, if sampling has not been done properly, the most carefully made tests are worse than valueless. For this reason, unless the inspector is prepared to spend the necessary amount of time in taking samples he should not attempt to make any tests whatever.

There are two points which must be borne in mind when sampling crushed stone and gravel aggregate. In the first place, the sample must be representative of the entire quantity being examined; and in the second place it must be large enough so that the largest individual piece will in no case weigh more than 2 per cent of the weight of the entire sample. When sampling crushed stone or gravel from cars or trucks a sufficient quantity should be taken from each end as well as from the top and bottom of the car to insure an average of the entire shipment. A shovelful taken from the top is not sufficient. A composite sample should then be prepared by thorough mixing after which it should be reduced by quartering until a sample has been secured weighing at least 50 times the weight of the largest fragment present.

In sampling from stock piles on the job, at the plant, or from bins the same precautions as noted above should be observed. Sampling from cars or trucks before or after delivery is much to be preferred to sampling from bins, because of the greater ease in obtaining average samples.

In sampling sand one of the principal precautions to be observed is to see that the sample taken contains an average amount of the loam or clay present in the shipment. Samples should be obtained whenever possible from damp sand, owing to the difficulty of obtaining a truly representative grading when the sand grains are dry. A composite sample weighing 10 lb. made up of samples from each end and from the top and bottom of the car should be taken.

Use of Apparatus.—In making a mechanical analysis of a crushed stone aggregate with this apparatus a number of points should be noted. The tripod should be set up and the circular spring scale suspended from it as close as possible to the material being examined. The shipment should then be sampled in accordance with the given suggestions. The whole sample thus prepared may then be passed through the various screens and the percentage by weight retained on each calculated; or, in the case of mixed aggregates graded up to 2 or 3 in. in size, a number of determinations may be made and the results averaged. It has been found convenient to make the original weight of each sample 10 lb. or some multiple of 10 lb. Inasmuch as the dial of the scale is graduated by one-tenth pound divisions, the various weights may then be read either as percentages direct or converted into percentages by simple calculation.

In making sieve analyses of sand or stone screenings less than ¼ in. in size the straight spring balance should be used. A 100 or 200-gram sample may be dried in any convenient manner and a mechanical analysis made in the ordinary way, using the interchangeable sieve plates. If a 200-gram sample is used the percentage of material retained on each sieve may be read direct from the scale. A mechanical analysis made in this manner on materials containing an appreciable amount of clay or loam, especially if it occurs as a coating on the sand grains, will not be absolutely comparable with a laboratory analysis. It will give, however, a fair indication of the grading of the material sufficient in most cases for control work.

Volumetric Silt Determinations.—Volumetric silt determinations should be made on all sand used in concrete work. Inasmuch as there is no definite relation between the silt content as determined by weight and by volume, it is recommended that the laboratory making the preliminary tests on the sand report the silt content in both ways. This will make it possible for the inspector to compare his results with the specification requirements which are nearly always written on the weight basis. The following suggested methods for making a volumetric silt determination may be used. A 250 c. c. glass graduate is filled to the 100 c. c. mark with water. Sand is then poured in up to the 100 c. c. mark after which the graduate is thoroughly shaken. After allowing the sand to settle until the water is approximately clear the volume of silt may be read and its percentage calculated from the total volume of the sand in the graduate. The line of demarkation between the silt and the sand is usually very distinct.

A quick determination in the field of the apparent specific gravity of an aggregate is sometimes of value, especially in the case of very heavy or very light material. It may be made easily and fairly accurately with the equipment described. A screen fitted with a loop of screen wire and suspended from the large spring scale is filled with the aggregate to be examined and its weight recorded. A 10-lb. sample may be used conveniently. The entire container, together with the sample, is then immersed in water and immediately reweighed. The apparent specific gravity may be computed from the loss of weight. An ordinary bucket of water may be used for immersing the sample. Numerous tests made with this apparatus indicate that results accurate to at least the first decimal place may be assumed.

Weight Per Cubic Foot Determination.—The determination of the weight per cubic foot is of value principally in the case of slag. The demountable box previously described affords a convenient way of making this determination on the job. The method so far used is to shake the material to refusal in layers of 3 in. each, striking the box upon the ground by rocking it back and forth 20 times after each layer has been deposited.

The systematic use of a field equipment similar to that described should prove of value both in the plant and field inspection of highway materials. A number of uses of the various units comprising the equipment will suggest themselves to engineers. For instance, the interchangeable sieves and small spring balance may be very conveniently used in sheet asphalt control work. In proportioning aggregates for various types of bituminous concrete roads, the outfit should prove of value. In fact, it may be used advantageously in any work in which a rapid determination of the size or weight of aggregate is desired.

Detailed information regarding the manufacture and use of any of the equipment described above will be given upon application to the Bureau of Public Roads.

The Call to Unity of the Engineering Profession

The secretary of the American Association of Engineers has issued the following "call to unity of the profession":

Unity of the engineering profession used to be desirable. Now it is a necessity, not only that the profession may retain its identity, but that it also may take the place in society which we think it should occupy. Unity can be accomplished, and that quickly, if we will but thoughtfully face the facts before us.

The engineering profession today faces the danger of being submerged in the controversy between capital and labor. In its position between capital and labor the profession should be represented as a matter of course at the White House Conference in October. Any invitation that may be received will come, however, only on request, and the engineer who attends will be regarded only as an onlooker. We can have a voice and be heard only by presenting a united front.

We say the engineer won the war. So must he win the battles of peace and take his part in the industrial readjustments where now justice, liberty and patriotism are swept aside in the struggle between capital and labor. As it is, organized labor seeks to divide the profession into the employer and employe classes. No calamity greater than this could befall the profession except to have it owned and at the behest of capital. The engineer's place has aptly been characterized as the third leg of the tripod on which modern industrial civilization rests. He belongs neither to capital nor to labor, but uses each for the purpose of accomplishing the greatest production for the happiness of mankind.

If he uses capital and labor to produce for the enjoyment of all men, why should he not plead the case of the neglected major third party, the public, in the struggles climaxing in the steel strike?

It can be done. Unity is close at hand.

The following resolution has been drafted for presentation to the Board of Directors of the American Association of Engineers at its meeting on Oct. 11:

Resolved, That the Board of Directors of the American Association of Engineers call a conference of representatives of all organizations or societies of engineers, architects and similarly educated or experienced technical men, for the purpose of strengthening the position of engineers and technical men as a group distinct from labor and from capital but essential to both and to society in general, because of the fact that stability of the social structure resting on the tripod of labor, capital and engineering, is dependent upon the strength of this third support.

How to Secure Best Results in Construction of Improved Granite Block Pavements

Practically the whole secret of the success of granite block pavement lies in the three items—proper paving, proper ramming, and proper grouting. The best practice for successfully handling these three items is described in a manual issued recently by Granite Paving Block Manufacturers' Association. The manual was compiled by Mr. Albert T. Rhodes, Field Engineer of the Association, and from it we have taken the notes that follow.

Granite blocks are produced in a quarry through successive subdivisions under cubical lines until finally the individual block is produced. No fracture results, or is imposed, on any individual block other than that along the dimension lines of the block itself, consequently the final block is in no way shattered as in the manufacture of crushed stone. The work is all done by hand, the larger breaks being made by aid of compressed air drills, shims and wedges following a line which has been traced by a stone chisel on the surface of the stone, for granite has a rift and line of cleavage similar to the grain in wood. It is injurious to the paving blocks to be thrown, in loading or unloading, from any great height, subjecting them to unnatural strains, to which, in their manufacture, they never have been subjected.

Standard Sizes of Blocks.—Several different sizes of blocks in common use are described below and it should be understood by the engineer or commissioner of highways, desiring to use this material, that any departure from these sizes will not mean any improvement in his construction, but will mean that he will be obliged, on account of the fact that schedules are arranged with granite paving block cutters at certain rates per thousand for cutting the blocks, to pay more for any special cut block deviating from these sizes with no added advantage to himself along construction lines.

5-in. standard paving block:
Length, 8 to 12 in.
Width, 3½ to 4½ in.
Depth, 4¾ to 5¼ in.

This block is the acme of perfection so far as granite paving blocks are concerned. Its length and width and cutting tend to produce the finest, smoothest type of paving. Its size is very favorable for freight shipment, it handles well in the hands of the paver laying the work and it looks well after the job is complete on the street. Not being too long, it lends itself to the crown of the street without breaking the continuity of the curve.

In connection with trunk line highway construction, hereinafter mentioned, this type of block lends itself extremely well; although on general heavy traffic street construction in the city limits it is customary to use a concrete base of various thicknesses and a 1-to-3, or 1-to-4 mortar cushion with the above blocks.

4-in. granite paving block:
Length, 7 to 11 in.
Width, 4 to 4½ in.
Depth, 4 to 4½ in.

This block is used very successfully on a concrete base on medium traffic streets with a 1-to-3, or 1-to-4 dry cement mortar cushion, grouted with a 1-to-1 cement grout or an asphalt mastic.

Resurfacing size granite block:
Length, 7 to 11 in.
Width, 3¾ to 4¼ in.
Depth, 3½ to 4 in.

This block is used very successfully where shallow depth pavements have been removed, leaving the original concrete base for use beneath this type of pavement, without disturbance of the concrete, necessitating no change in gate boxes, manhole tops, or catch basin frames. A durable, economical substitution for many of your worn-out pavements at a minimum of cost.

The following are general specifications governing the construction of the several different types of pavement, using granite block as a wearing surface, preceded by various foundation specifications common to the several different types described.

Drainage and Subgrade.—Drainage of the subgrade to every extent which is practical of course is one of the primary requisites for this or any other type of pavement.

Any subgrade should be properly compacted by rolling or ramming, so far as is possible, all soft or spongy material removed and the holes filled and rammed to a true and uniform subgrade throughout.

Concrete Base.—General concrete specifications of the American Society for Municipal Improvement or any other standard specification may be followed. The cement concrete base should be in any case not less than 4 in. thick and running from that up to any depth deemed sufficient to span over any subgrade settlements, such as ditches and the like. The concrete base in general may be mixed in the proportions of 1 part cement to 3 parts sand and 6 parts crushed stone, although the writer's preference would be 1, 3 and 5, for the reason that if the stone aggregate is not properly graded and the large size stone is used, and possibly the sand be extremely coarse, difficulty will be experienced in getting a full and compact concrete bed for the paving to rest upon, there not being sufficient mortar to flow into the interstices of the crushed stone and form a tight base. Also, labor being an extremely important feature as far as the cost is concerned on any such proposition, it really will be found cheaper in the end to sacrifice the sixth part of the crushed stone in order to easily produce a compact mass for the foundation without the continual expense of labor in working the concrete to fill all the voids occurring in the coarser mix.

Sand or Mortar Cushion.—Sand for this purpose should be clean, sharp and coarse. For the mortar cushion the proportion should be preferably 1 to 3, but not less than 1 part of cement and 4 parts of sand by volume, mixed dry. The cushion course may be dampened slightly, if desired, at the time the paving is laid upon it, but should in no case be made of a "sloppy" consistency; and should not be mixed more than one-half hour ahead of its use under the paving blocks on the bed, and no material should be left over, mixed, at the end of one day's work, and used without the addition of the full amount of cement on the resumption of work. There are several reasons for the incorporation of the cement in the cushion course.

The effect of the mortar cushion course on the pavement is as follows:

It subdivides the bearing of the blocks over the subgrade or concrete base upon which it is placed. It creates a monolithic pavement from top to bottom. It unites with the grout of the joints, forming a continuous bond around and under the paving blocks and, should the blocks have been improperly rammed to a true and full bed in the cushion, the setting of the cement in the mixture retains the particles of sand in the cushion course in their original position underneath the blocks, preventing them, through impact of travel and vibration caused by travel on the surface of the roadway, in shifting their position underneath the block, and from shaking, settling and rattling away from underneath the paving block, improperly rammed, leaving it suspended in the air and held only by whatever grout surrounded it.

Laying the Blocks.—On a properly prepared cushion the blocks should be laid in courses at right angles to the lines of the street, and in a straight line from curb to curb, except in special cases, when they shall be laid at such an angle as may be directed by the engineer. The blocks shall be laid as closely as possible, each block touching the adjoining one on sides and ends, and in courses of uniform width. All joints shall be broken with a lap of at least 3 in. The blocks shall not be laid more than 25 ft. in advance of the ramming.

Extreme care should be taken in the laying of the blocks that the common fault is not incurred to which many pavers are prone; that is, the crowding of the grade line. This crowding of the grade line is a habit easily acquired by a paver and tends to produce a pavement in a series of waves, on account of the fact that as the paver gradually approaches the point to which his grade line is attached he naturally, after crowding the line in the slack, in the center, reduces the crowding as he approaches the point of support of the line. Also many pavers are apt to lay the blocks high against manholes, catch basins and the like, causing shock to the pavement after it is open to traffic and consequent damage through the fact that the wheel will drop into the depression caused by the manhole or catch basin frame, and then bump up against the surrounding paving, producing a trip-hammer effect greatly detrimental to the paving.

Owing to the fact that the paving blocks vary in depth to a slight degree, a skilled paver will sometimes keep the shallow blocks high and the deep blocks a trifle low as compared to his grade line; in this manner averaging the blocks so that they will ram to a truer surface.

Different types of paving hammers are used in different sections. The type of hammer with the narrow or medium width blade (with considerable length from the eye to the end of the blade) by the use of which the paver after making his bed, hooks one end of the stone and places the stone on its bed, without laying down the hammer, seems to be productive of faster work than the short, shovel-bladed hammer in use in some sections of the country. Those using the short, shovel-bladed hammer invariably lay the hammer down, grasp the block with both hands, placing it on its bed. Whereas this may seem a small matter so far as each individual block is concerned, the loss of time in thus laying down the hammer and picking it up again amounts to considerable in a day's work and from general observation of the work of pavers using these two different types of hammers, those using the long-bladed type seem to accomplish more in a day and do it easier.

Ramming.—In the ramming of the blocks each block should be rammed individually to a solid bearing, there being some little difference in the depth of each individual block as indicated in the specifications of size of blocks previously dwelt upon. It will be seen that it is absolutely necessary that each individual block shall be rammed to a full bed and should this cause the block to settle below the final finished grade of the pavement, such blocks should be removed with paving tongs, an added amount of cushion material supplied, and the block again rammed to a true and even surface with the rest of the pavement. Rolling does not produce proper results as it does not properly ram the shallow blocks, but rocks them back and forth on their beds and forces the bedding material up between the blocks, displacing the good grout which should be there instead of the poorer bedding material.

The reason why paving tongs are specified is that if the ordinary method of pinch bars is used in removing the low blocks, pressure is brought to bear on the edges of the surrounding blocks already rammed, causing them to rock on the bed in which they were originally rammed and dislocating the surrounding blocks materially.

The ramming of the blocks is one of the most vital features in the construction of a pavement. This should be done by a man skilled in this particular branch of the craft, who has a true eye—as upon his effort the final finished, true contour of the street depends, and poor ramming can spoil paving laid by any of the best pavers.

Each individual block should be struck squarely in the center, and not rocked back and forth either sideways or endways by successive tappings on either sides or ends. Blocks to be rammed to properly meet gate boxes, manhole tops and catch basins.

The rammers used are of various types in various sections of the country. The type most in use in the New England States is a rammer weighing about 50 lb., with a handle on the top and one on the side, worked by one man. The bow type of rammer used in the vicinity of New York City and throughout a number of other districts in the country is also a one-man rammer with a bowed handle springing from opposite sides of the rammer and curving around the top of the rammer for a hand-hold at that point. This is a lighter rammer of about 35 lb. In the Central West a large two-man rammer is used, the bottom surface of which covers more than the area of one block. This has a handle on the top and a handle extending through on either side of the rammer, the top handle and one of the side handles being grasped by each man, ramming being done by the men working in unison.

Cement Grout.—Through comprehensive study of many pieces of pavement laid for varying periods of years, up to 20 years and over, it is the writer's opinion that the best wearing grout produced has been that in proportion of 1 part cement to 1 part of sand. This grout makes a dense mixture which conforms more nearly than any of the others to the wearing qualities of the stone it surrounds, and adheres more closely to its surfaces.

The methods of mixing grout in common use are by machine and by hand, of which the machine mixing is by far the more preferable, owing to the fact that a machine continually agitates the grout up to the time of its discharge onto the pavement, whereas by hand work it is almost impossible to keep the grout sufficiently agitated so that the sand will not settle and separate from the cement. This is true in a great measure as the sand increases in coarseness, and still it is not wise to use too fine a sand, as good results are not obtained with sand of this nature. The most ideal sand, particularly for hand mixing, seems to be a sand of nearly uniform composition and one which will all pass a 20-mesh screen.

There are different types of boxes used in the hand mixing, some having legs of unequal length, so that the grout will be thrown to one low corner; the material, after mixing, being either dumped directly out of the box onto the pavement and then broomed into the joints, or taken out of the mixing box by scoop shovels and deposited on the work. This idea of taking the material from the box with scoop shovels has always seemed a considerable waste of time, the idea being, that there will be no chance of settlement of the sand, the entire box of material being agitated continually while it is being scooped out.

The most practical box mixer is one resting directly on the pavement, having a gate in the end which is lifted up, after the grout has been properly agitated and mixed, entire mass being then drawn out onto the pavement by the mixing hoes which had been used to agitate the grout.

The machine mixer is much the better proposition, the material being constantly agitated, but in using a machine mixer great care should be taken not to spill unmixed materials on the pavement and into the joints while getting them into the machine, and also that materials shall not be dropped or shaken out of the machine on the pavement or into the joints during the mixing process. Also, when the machine is washed out at the end of the day's work, the washings from the machine should not be deposited on the pavement.

The grout when applied should be of a consistency which will readily flow throughout the joints of the paving blocks, but which will not be so thin that the cement separates from the sand and flows away in the gutter lines. There is some shrinkage in the setting of the cement grout. This should be taken care of by continuous brooming operations until such time as no further perceptible settlement occurs in the joints, at which time all excess grout should be removed from the top of the paving blocks and the joints left absolutely flush with the top of the blocks, care being taken that they are not broomed out below the surface of the blocks by too vigorous brushing. The best results are being obtained by a final finished brooming with an ordinary bristle house broom, which leaves a smooth, even surface without raking out the joints.

In the matter of sand for the grouting, too much care cannot be taken to avoid detrimental foreign materials, particularly loam and clay, which if they occur to any extent in the sand will kill the effect of the cement, producing a chalky, powdery grout with no strength after drying out. A rough and ready test of sand can be easily made by an empty bottle, a handful of sand and a little water. After thoroughly shaking the sand and water together, the contents of the bottle after settling at the end of a short period will show successive layers of fine material, the loam and clay showing at the top. Under no circumstances should the sand show more than 10 per cent of loam or clay and if any sand can be procured showing less than 5 per cent this sand should be obtained in preference.

It was the custom at one time, in advance of the application of the grout and previous to the ramming of the blocks, to incorporate in the joints a varying amount of peastone; but this is an extremely dangerous practice to follow, and if it is absolutely desired to use peastone, the peastone should be wet and thrown into the grout as it comes from the machine or mixing box, and broomed into the joints with the grout. This original practice of incorporating peastone in the joints led up, more readily than any other feature in the paving construction, to improper results. Dishonest contractors were prone to fill their joints nearly flush with the peastone, the grout on reaching the peastone never went below that point and very poor paving results were produced.

Another distressing feature oftentimes produced by either leaving too much sand in the bottom of the joints or by this malpractice with peastone, is that owing to the two factors of expansion and contraction, and to the fact that the block is not rigidly held around the bottom, only a shallow collar of cement grout surrounding the top side surfaces of the block, the impact of travel striking upon the top of the block kicks the bottom to either one side or the other, splitting the top of the block off in a similar manner to the successive layers of an onion. From this particular feature many times engineers and others interested have claimed that the paving blocks were "soft" but no instance has ever been cited where blocks from the same quarry laid in a sand joint have ever become broken. Blocks laid with a sand joint or soft filler will cobble on the edges of the top, forming the turtleback effect, but will not break up.

Sometimes if the paving blocks are dirty, or have a film of oil the grout will not obtain a proper hold on the sides and difficulty will be experienced through their letting go. When the grout once "lets go" no further sustaining power can be expected from it, and the only possible repair is a complete replacement with new grout in the joints.

Around the web and flanges of street railway tracks much better results are obtained by allowing the grout to fill in against the rail, care being taken to add more grout as the shrinkage in setting takes place, through this method a toothing bond being accomplished with the rail area grouting at each joint between the different blocks abutting on the rail. Cases have come to my knowledge where this grout in connection with the blocks supported the railway iron for at least three years after the ties were rotted so that they gave no further support to the rail.

Barriers.—In connection with the cement grouted paving, too much care cannot be taken in regard to protecting newly grouted work. Should the bond between the grout and the block become broken it never will mend. Proper barriers should be erected which will keep traffic from going on the fresh road work and these should also carry warning signs of sufficient emphasis to impress upon the minds of those approaching such work the damage which they are about to inflict upon the work if they travel over it. A watchman at night is an absolute necessity wherever there is any question of travel entering upon the work. A watchman is particularly advantageous on car-track streets where the barriers cannot be placed close to the rail on account of the passage of cars and where the vehicular traffic is apt to run with one wheel outside the rail on the freshly laid pavement.

Expansion Joint Strips.—These are sometimes used against street curbing, extending from the top of the finished grade to the bottom of the concrete base, if one is used. This in a great measure eliminates any vibration which might occur through the curb, and granolithic walks communicating to the building adjacent. Joint strips are absolutely unnecessary transversely in the roadway.

Protection in Freezing Weather.—Protection in cases where work has to be done in freezing weather can be best accomplished by the use of fine sawdust, preferably pine, as oak or chestnut would be apt to stain the pavement temporarily leaving a very disagreeable looking piece of work, but otherwise not harming it in any way. It will be found that a thin layer of sawdust is a very efficient protection against severe cold. This material is light, easily handled and spreads readily over the surface of the pavement, and if necessary can be covered against rain by rolling out tarred felt over the top. It is very much more effective than hay, straw or marsh grass and will cover much easier.

Grooving on Hillsides.—Where the cement grout is used on hillsides and steep inclines, in order to provide a toehold for horses, the grout in the joint is sometimes raked out for about ½ in. in depth, with a tool resembling an ordinary poker, or by stiff brooming. But owing to the fact that ordinarily no difficulty is experienced in this manner until about 5 years after it is constructed, it is better practice, although a little more expense, to wait until such time as difficulty is experienced, and then with a tool similar to a pean hammer, or else with compressed air tools, cut channels at each joint, making the proper grooving for toehold for horses. In this manner a much better riding surface is obtained than if the joints are raked out or broomed out at the start.

Track Blocks.—It often becomes necessary to pave against tee rails, street railway construction. In this case a special block is cut, taking the place of the flange on the grooved girder rail, to receive the flange of the car wheel.

Trunk Line Highway Construction.—A modification of the above type of pavement is adapted to trunk line highway construction. Using the same form of sub-grade construction as would be used in connection with any of the other types, on this sub-grade, properly compacted, a cushion course of at least 1½ in., after ramming of the pavement, of 1 to 3 dry cement mortor cushion should be placed and the blocks paved on this cushion course. After the blocks have been rammed the pavement should be sprinkled with water to assist in setting up the cushion course and also to more properly bond the 1 to 1 grouting, which is to follow, to the blocks themselves.

Bituminous Mastic Grouted Pavement.—In some of the most densely populated cities of the country, where it is often necessary to make frequent openings in the pavement, which necessitates easy removal of the material where traffic conditions are such that it is not practical to close the street for any longer period than is absolutely necessary and where it is desired to use the material on hillsides, giving toehold for horses, this method of grouting with bituminous mastic filler is sometimes a great advantage. Naturally, with such construction each joint in itself becomes an expansion joint and noise eliminator.

Many of the heaviest traffic streets in the Borough of Manhattan are paved with this type of paving. The method pursued in the construction of this type of paving is as follows:

The paving and ramming are carried out in the same manner as has been previously explained for a cement grouted pavement. The sand to be used in this mastic grout filler is generally of the usual consistency of the best quality cement sand, but should not contain pebbles larger than those retained on a 20-mesh screen. In the case of tar pitch filler the sand should be heated to a temperature of not less than 275° and not more than 350° F., and shall be between these limits when mixed with the paving pitch.

If an asphalt filler is used, the sand should be heated to a temperature of not less than 300° or more than 400° F. and shall be between these limits when mixed with the cement.

The sand is usually heated either over piper heaters or some portable heating device, or it is sometimes heated at a large bituminous mixing plant and drawn in steel-bodied conveyances, hot, to the job. The bitumen is usually heated in portable kettles on the work, but is sometimes transported in tank trucks from plants, if conveniently situated in the immediate vicinity of the work.

Methods of Mixing.—The methods of mixing the mastic to date are extremely crude and simple and no doubt will soon be improved by the introduction of proper mixing machines. The general custom today is to mix the bitumen and sand together in the ordinary steel wheelbarrow, first pouring the bitumen into the barrow and then adding the sand, mixing with a steel squeegee, until the proper consistency is obtained. The same effect is also accomplished by using the ordinary two-wheel concrete push-cart, in which the axle extends through the body of the machine and is equipped with paddles which churn the bitumen and sand to the proper mixture with a few turns of the wheels of the machine.

Filling Joints.—The mastic is then dumped on the surface of the properly rammed pavement and is pushed and squeegeed into the joints with a steel squeegee, filling the joints from top to bottom and usually leaving on the top of the blocks a slight mat of mastic which later wears off under travel. This produces, when first constructed, one of the quietest known pavements in existence.

As in the case with the cement grout, the work of the pavers should be closely followed by the application of this mastic, and no grout should be applied in wet joints, or with water lying underneath in the joints. This mastic mat is immediately covered with a light coating of hot sand, which prevents the mastic from adhering to the traffic passing over it. The work can be immediately opened to travel as soon as the mastic is cool, which would be, usually, within half an hour at least.

The oldest sample of this pavement, of which we have knowledge, is on Amsterdam Av., New York, 5 years of age and in first class condition.

Salvage in Old Granite Blocks.—There are several ways of reconstructing this pavement which give extremely gratifying results.

If the pavement was originally laid with a sand joint and has not been turned too many times in relaying, it will be found that very satisfactory results may be obtained by turning the faces, which have not been worn, up and grouting, as in the case of new blocks, with a 1 to 1 cement and sand grout. They may also be used with a bituminous mastic joint, but in general are not cut sufficiently close to lend themselves to first class work with this filler. The neatest and nicest results, however, are obtained by what is known as napping the blocks. To successfully accomplish this result it is necessary that the old blocks shall be reasonably long so that by napping or cutting one through the center it will produce at least two fair sized blocks. If the blocks are not long, as above mentioned, they will usually have to be recut and the waste is very considerable in such cases.

It is very essential in the use of second-hand blocks that the blocks from different quarries should be separated and used by themselves, and rigid inspection should be given all second-hand material, because in the early days of the production of granite paving blocks very little attention was paid to the quality of the stone and very little inspection given as to whether it was disintegrated stone, not well fitted for construction purposes; consequently a considerable part of the stone originally laid would not be considered today fit material for construction purposes. Such disintegrated material should be culled out and not used in the construction of a pavement, but placed in gutters for other type streets.

Napping Second-hand Blocks.—To nap a block a mark is made across the center of the block with a stone chisel, tracing on a straight line. The block is then turned over and struck a sharp blow with a stone hammer, fracturing opposite the tracing first made. This will usually split the block in a very clean break on the line of the tracing, following which the block is trimmed up, usually cutting off the turtleback effect on one side, and the new face becomes the top of the block exposed to wear. Some extremely durable and desirable jobs are produced in this manner, using either the cement grout or the bituminous mastic joint.

Missouri Valley Road Builders' Association Organized.—At a meeting of contractors, representatives of material companies, county, state, municipal and Federal engineers, held in Kansas City on Sept. 2, it was decided to organize what was afterwards termed the Missouri Valley Road Builders' Association. The purpose of this organization is to promote the mutual welfare of the highway industry and to attempt to place it before the public on the same basis as other industries. The organization has for one of its primary purposes the idea of bringing closer co-operation and better understanding between contractors, engineers, material companies and highway officials in general. The present efforts of the association will be directed toward obtaining a recognition from the railroad administration of the highway work and procure the proper car service for highway materials. The officers elected were as follows: Chairman, M. W. Watson, State Highway Engineer of Kansas; secretary-treasurer, M. R. Amerman, contractor, Salina, Kansas, and an executive committee composed of the two above named officers and S. A. Fones of the Independent Gravel Co., Joplin, Mo., A. W. Graham, State Highway Engineer of Missouri, and R. E. O'Brien of the Cook & O'Brien Construction Co.

The meetings will be held monthly on the third Saturday of each month at 10 a. m. at the Baltimore Hotel in Kansas City, Mo. The membership is open to all highway officials, state, county, municipal and Federal, to all contractors and to all material companies and concerns. The territory to be covered by this organization comprises the states of Missouri, Kansas, Nebraska and Oklahoma.

Weather Reports on Highways. The highway weather service, one of the new enterprises of the United Department of Agriculture, operated through the organization of the Weather Bureau, is proving of benefit to automobile owners where it has been tried. The meteorologist in charge of the Weather Bureau office in Kansas City, Mo., recently reported: "The demand for a road reporting service is quite general and insistent and it will continue so, increasingly, until dirt roads become an anachronism. This office established a road or highway reporting service April 1 of this year and, without exaggeration, it is equal to the most practical service which our office otherwise can perform. It amounts to the direction of public motor travel, and persons start or postpone trips as we advise." The highway weather service was begun as a war measure in aid of motor transportation and was conducted with emergency money until the end of the war. Though Congress made no appropriation for its continuance during the present fiscal year the demand for it is such that the department is endeavoring to continue it without special funds to meet the expense.

A Simple Method of Computing and Showing Overhaul

By EDWARD H. STEELE,
Assistant Construction Engineer, Minnesota Highway Department

The diagram shows a section of profile with accompanying cross-sections and actual computed quantities, together with mass-diagrams and overhaul. The method of procedure is as follows: With the grade line as shown, plot the cross-sections, planimeter the areas, and compute the quantities of excavation and embankment separately as indicated.

Find the first station at which the grading quantities change from an excess of excavation to an excess of embankment, or vice versa, allowing for the assumed shrinkage (10 per cent used in the diagram); that is, increase the embankment quantity by 10 per cent before comparing it with the corresponding excavation quantity. In making the shrinkage allowance it is unnecessary to go into refinements. Quantities should be computed to the nearest cubic yard and the mass diagram platted to the nearest 10 cu. yd.

Having thus determined the starting of zero point of the diagram, plat, in the direction in which it occurs, the excess of excavation and the excess of embankment, making the allowance for shrinkage at each station as described above.

Assuming that the work starts at station 132 + 80, the platting should continue until a point is reached where the sum of the actual excavation quantities (shown on the cross-sections) exceeds the sum of the embankment quantities by approximately 10 per cent—i. e., at station 139 + 00 where excavation equals 970 cu. yd. and embankment equals 819 cu. yd. This then forms one complete diagram, with the grade line shown, and the following ones are plotted in exactly the same manner. The vertical scale may be varied to keep the diagrams within limits vertically.

Overhaul is measured and paid for in units of cubic yards hauled 100 ft. or fractions thereof, beyond the free-haul limit of 500 ft. The method of computing overhaul is as follows: Connect the upper limits of the diagram by a dashed line, and draw the free-haul line (500 ft. long) where it just spans the diagram parallel to the dashed line. Draw in similarly the 600-ft., 700-ft. and 800-ft. lines (shown dotted station 139-148). All the material below the 500-ft. line represents the balanced amounts of earthwork (10 per cent shrinkage allowed) within the free-haul limit. Scale off vertically, with the scale used in platting the diagram, the quantity between the 500 and 600-ft. lines (180 cu. yd.). This is to be hauled 100 ft. Scale off the quantity between the 600 and 700-ft. lines (220 cu. yd.) and multiply it by 2 since it must be hauled 200 ft. Continue this process throughout the diagram and the summation of the results gives the amount of overhaul required.

This method is simple, sufficiently accurate, and shows at a glance the direction (slope of dashed line) and limit of haul with the actual quantities involved. It has the advantage over methods requiring a continuous mass diagram, of not necessitating the replatting of previous diagrams when a change in grade line is made during the process of design.

All the figures necessary in platting these two diagrams, together with all the earthwork quantities, are shown in order that those interested may check up the results indicated.

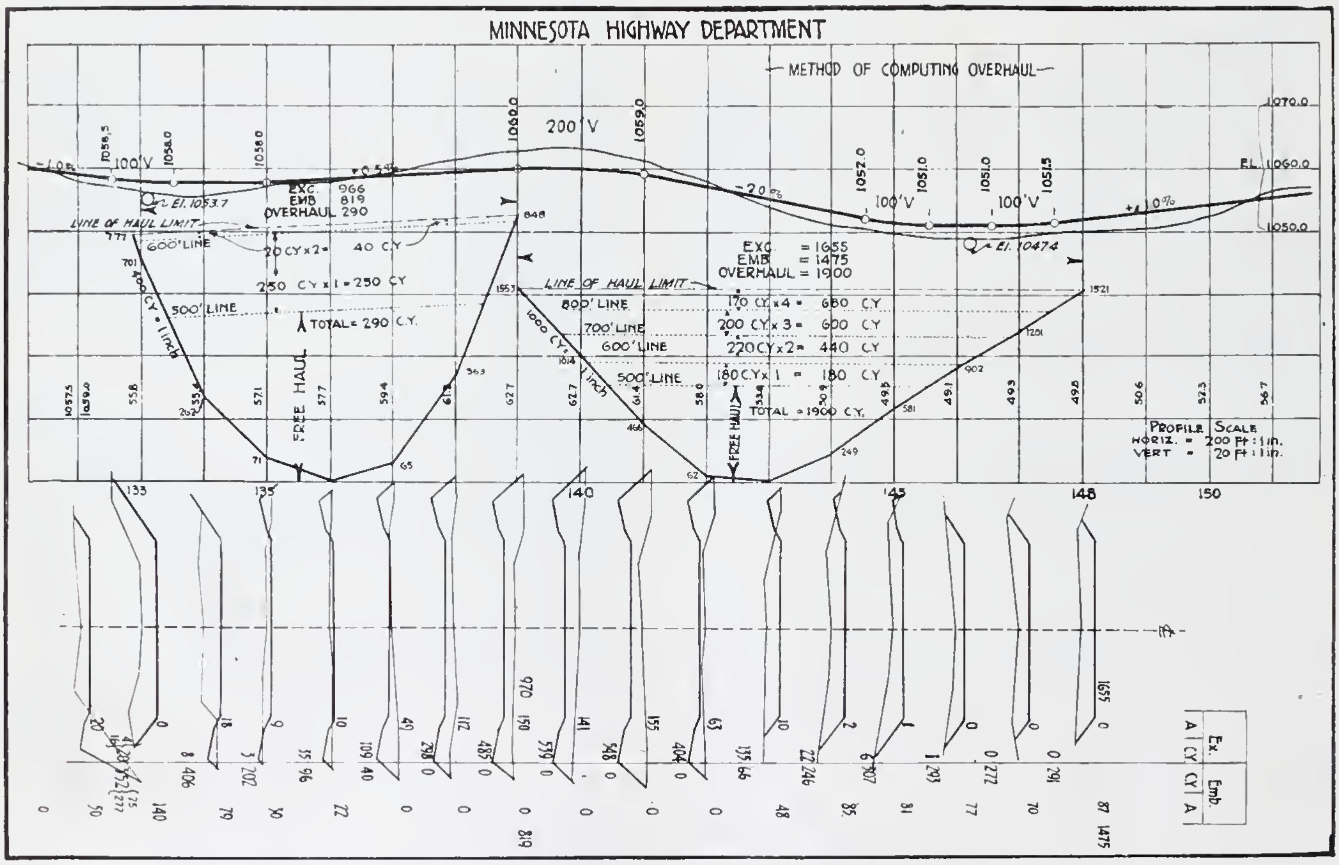


Diagram Showing Method of Minnesota Highway Department for Computing Overhaul.

Amount of Water Per Batch of Concrete.—In constructing a Federal Aid concrete road near Denver, Colo., experiments were made on the water required in the mix. As a result it was determined to use water per batch as follows:

17.7 gal. per batch or 33.8 gal. per cubic yard of concrete, producing a rather stiff mix which, when screeded and screed tamped, gave a very satisfactory surface upon which no excess water appeared. Or 19.1 gal. per batch or 36.5 gal. per cubic yard of concrete, producing a mix which flowed slightly and when screeded and screed tamped gave a very satisfactory surface upon which a slight amount of water appeared. The concrete was mixed in the proportion of 1 bag of cement to 2 cu. ft. of sand and 3 cu. ft. of screened gravel, and results from the total pavement laid showed that 1.7 bbl. of cement were used per cubic yard of concrete, which was mixed to such a consistency that when struck off with the strike board the exposed face stood up almost vertical, no flow occurring and there being no separation of material. The concrete mixer used was a paver with a rotary distributor and the results obtained were very satisfactory. The batch consisted of 3½ bags of cement, 2 wheelbarrows of sand and 3 wheelbarrows of gravel of 3½ cu. ft. capacity. It required just 100 seconds to mix one batch. Eighteen batches were required for a 30-ft. block, and as this block was laid in 30 minutes the normal running time was 1 lin. ft. of pavement per minute.

Two Years' Record of Maintenance Costs of Primary Roads in Washington

On June 7, 1917, the state of Washington inaugurated the plan of state controlled, county administered maintenance of its primary highway system. At the outset, 1,245 miles of constructed primary roads come under the operation of this system. By June of 1918, by completion of new construction, the mileage had increased to 1,410 miles, and in July, 1919, completed new construction and additional routes designated by recent legislation as primary highways, brought the total mileage under the joint maintenance plan to 1,796. This mileage will continue to increase at the rate of 200 to 300 miles annually for the next three or four years until the entire 2,700 miles of designated primary highway system is completed with permanent construction. Although this primary mileage comprises only about 5 per cent of the established road system throughout the state (excluding streets within corporate limits of cities and towns), it is certain that at least 50 and perhaps as much as 75 per cent of the entire volume of highway traffic is carried by these primary routes upon which the through and local traffic is concentrated.

Two years of cumulative cost-keeping records of primary highway maintenance are now available. In the July issue of Public Roads, Mr. E. G. Cotterill, chief engineer of the Washington State Highway Commission, summarizes these costs and deduces some general conclusions from them. The following is abstracted from his article:

The record covers about 250 separate sections of highway, each averaging nearly 6 miles in length, and including 11 types of construction and surfacing. The maintenance was under the direct administration of 30 boards of county commissioners, the county or maintenance engineer being in direct charge. During the year June, 1917-May, 1918, these 30 counties cared for a total mileage of 1,303.87 of primary highways at an average cost per mile for maintenance, repairs and equipment of $327.84. During the year June, 1918-May, 1919, the mileage was 1,512.79 and the average cost per mile was $419.86. The annual average cost per mile year was $373.85. The following table shows the expenditures in 1917-18, classified according to construction types:

The expenditures include all charges upon the entire road, its drainage, roadbed, slopes, shoulders, etc., as well as the pavement or surfacing—everything that has been necessary for the adequate maintenance, repair, and general upkeep of the highway.

Equipment purchases make up about 15 per cent of the total expenditures, varying from nominal up to 50 per cent in the various counties, apportioned upon the respective highway sections to which applied. While this operates fairly as a general state average, there are disproportionate equipment charges as between the several counties, which will not work out in fair comparison until at least four or five years of continuous records on this plan are made available.

On certain sections of the McClellan Pass Highway in King county and of the Olympic Highway in Clallan and Grays Harbor counties, the Federal government spruce operations of the war period imposed a most abnormal and destructive use upon more than 100 miles of gravel-surfaced highways. Extension trucks carried great logs, often to aggregate weights of 20 to 25 tons, over miles of roads unfitted for such abnormal use; but with no other transportation resource from the spruce forests, these roads were devoted to the national service. In order to keep up these roads under such traffic, it required on the McClellan Pass Highway in King's county an expenditure during 1918 of $1,861.37 per mile for the 19-mile section east of Enumclaw, which was the scene of the spruce-hauling operations. Similarly on the Olympic Highway in Grays Harbor county south from Lake Quiniault it cost almost $1,000 per mile to keep up the 37 miles of gravel-surfaced highway during 1918. These abnormal upkeep costs swell the figures from these counties and types of highway.

The years covered by the statements, beginning with June 1917, have witnessed the highest scale of labor and material costs every known. Common labor had reached the $3.75 mark before June, 1917, and rose to $4.50 and $5 during 1918 at which level it remains in June, 1919 (for day of eight hours). This represents a full 100 per cent increase from the $2.25 to $2.75 rates for similar labor in the prewar period. And the materials necessary for maintenance work have risen in almost similar doubled proportion. The Washington primary highway average of almost $400 per mile maintenance cost in 1918—and five months of 1919 shows a continuance at about this rate—is fairly comparable with $200 per mile during the period of 1910-1916.

At least one general conclusion is fairly deducible from the Washington figures of two years' maintenance costs, viz., that there is a gap of $250 to $300 per mile year between the group of hard-surfaced paved highways and the macadam-gravel group. Considering further that the paved highways carry a volume of traffic per mile, averaging two to ten times that of the macadam-gravel group, it is demonstrable from detail analysis of sectional reports that macadam-gravel sections under traffic comparable with paved sections are costing from $600 per mile per year and upward for their upkeep. In other words the real gap between maintenance cost of paved and macadam-gravel highways under similar heavy traffic is at least $500 per mile per year. Assuming a traffic of 500 motor vehicles per day or 182,500 per year, it is certain that not less than 1 ct. per mile—some would place it as high as 2 ct.—will be saved to the motor operating public, or $1,825 per year per mile, in actual upkeep cost of motor vehicles employed, to say nothing of increased traction results, time saved and convenience served. Adding the $500 per mile of increased annual maintenance cost and $1,825 per mile of motor vehicle upkeep cost makes a showing of $2,325 per year per mile which can be saved by substituting a hard-surface pavement for macadam or gravel surfacing. Half this amount would pay the interest on an investment of $25,000 per mile in pavement.

Whenever the traffic on a macadam or gravel surfaced highway approaches an average of 500 motor vehicles daily the Washington experience, demonstrates costs of $600 to $1,000 per mile for such uneffective degree of upkeep as is possible for these highway types under such traffic. In every such case a hard-surface pavement is economically over-due, and the Washington program is to get these roads up to date by hard-surface construction as fast as resources and credit will permit.

Instructors Wanted for Motor Transport Training Schools. The United States Civil Service Commission is receiving applications to fill 150 positions of assistant instructor in the motor transport training schools of the army. The entrance salaries range from $1,800 to $2,400 a year. Detailed information may be obtained from the U. S. Civil Service Board at the post office or customhouse in any city.

EXPENDITURES, 1917-18, CLASSIFIED BY HIGHWAY CONSTRUCTION TYPES

Type of surfacing	1917 (7 months June-December) Mileage.	Per mile	1918 [illegible] Mileage.	Per mile	1917-18 [illegible]
Brick pavement	8.81	*$1,073.38	[illegible]	[illegible]	[illegible]
Cement concrete	90.79	56.41	[illegible]	[illegible]	[illegible]
Asphaltic concrete	19.74	16.32	23.21	[illegible]	[illegible]
Bitulithic and warrenite	14.41	211.00	17.77	[illegible]	[illegible]
Sheet asphalt	5.97	51.61	[illegible]	[illegible]	[illegible]
One-half width concrete, one-half width macadam, etc.	7.80	[illegible]	[illegible]	[illegible]	[illegible]
Bituminous macadam	42.21	139.67	[illegible]	[illegible]	[illegible]
Water-bound macadam	122.87	165.2[illegible]	[illegible]	[illegible]	[illegible]
Crushed rock surfacing	51.02	155.41	[illegible]	[illegible]	[illegible]
Gravel surfacing	756.33	182.72	[illegible]	[illegible]	[illegible]
Natural earth grade	121.28	86.67	[illegible]	[illegible]	[illegible]
Special, bridges, trestles, etc.	1.55	....	[illegible]	[illegible]	[illegible]
All types, total	1,215.57	$169.26	[illegible]	[illegible]	[illegible]

*Abnormal expenditures on brick pavements due to extensive repairs and [illegible] settlements. The 1917-18 average per mile year obtained by adding annual averages and equal division [illegible] types than brick, the 1917-18 mile-year average is obtained by dividing sum of annual averages by 1.58 [illegible] averaged with full year 1918.

70.4 Lin. Ft. of Concrete Road Per Hour

Remarkable progress on a concrete road job was made last summer in building a highway between Coldwater and Batavia in Branch County, Michigan. According to the records of the contractor and the engineer inspector of the State Highway Department 15,847 lin. ft. of 16-ft. pavement were laid in 225 hours, an average of 70.4 lin. ft. per hour. The high run was 126 lin. ft. per hour.

A 55 cu. ft. capacity mixer was used on the work. This machine weighed approximately 12 tons, but the great width of the tire of the wheels made planking of the subgrade unnecessary. The mixer was not self-propelling and was moved by the tractor which handled the derrick. Another part of the outfit which materially aided in speeding up the work was a central proportioning plant. This was located alongside a switch from the railroad, and included three material bins. The bin for cement was stationary. Bulk cement was delivered in gondola cars equipped with heavy canvas covers. The cars were ranged alongside the bin and unloaded by a crane into the bin. The bins for sand and stone on either side of the cement bin were built on flat cars moving on a dead end track. The crane, equipped with a clam shell, was mounted on a flat car, was self-propelling, and shifted the sand and pebble bin cars where necessary.

Material boxes of 55 cu. ft. capacity, one on each chassis of an industrial train, were drawn alongside the gravel bin first, each box receiving 30 measured cubic feet of stone. Teams move this string of cars ahead, under the cement bin, where 10 measured cubic feet of cement were deposited in each box. A little further ahead the cars were drawn alongside the sand bin and each filled with 15 measured cubic feet of sand, thereby completing the proportion. Pushed ahead, the train of cars was coupled up, ready to be drawn to the mixer by gasoline locomotives.

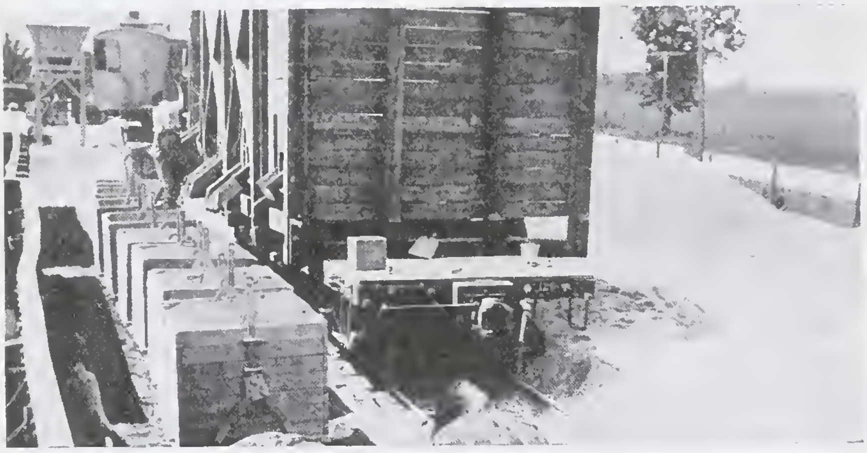
As the distance from the proportioning plant to the mixer increased the delivery became more difficult. With the addition to the equipment of a third gasoline locomotive, however, there was now practically no difficulty in keeping the mixer supplied.

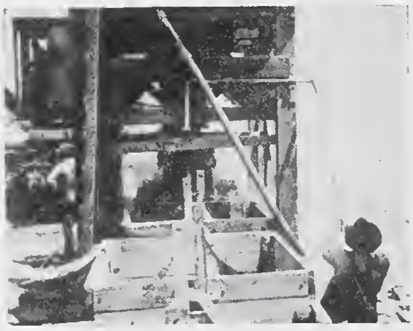
Arrived at the mixer, the material boxes were lifted from the truck by a motor derrick, swung into position over the hopper of the mixer and there emptied by an ingenious contrivance, worked by the derrick operator. This dumping device, together with the material boxes, was designed by the contractor, the boxes themselves being constructed in his own field shop.

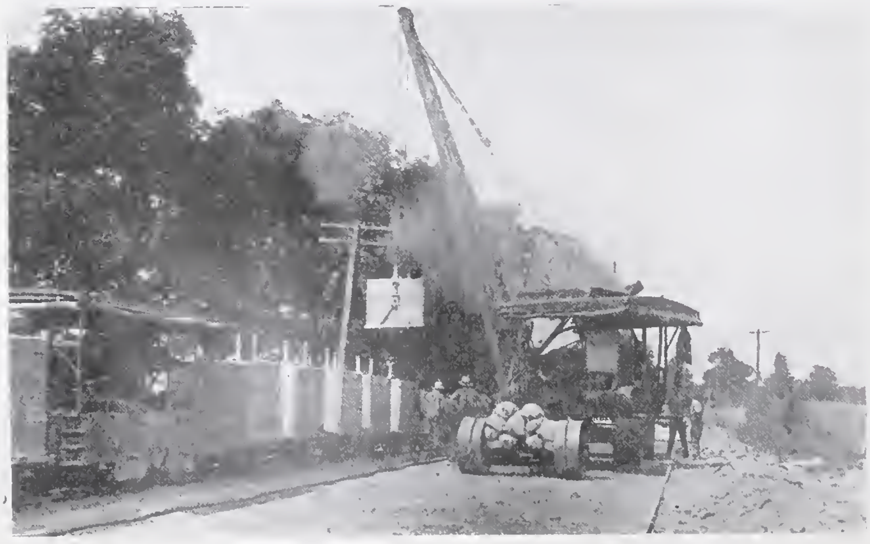
Standard methods of finishing and curing were followed, a steel shod template striking the concrete to the required crown, a roller pressing out excess water, the finish was secured with a wide canvas belt, and the surface on each side of the joints was brought to exact level by a 4-ft. split float. An edging tool was used at the sides of the pavement and canvas covers were placed over the finished sections during hot weather. The contractor for this work was G. P. Scharl.

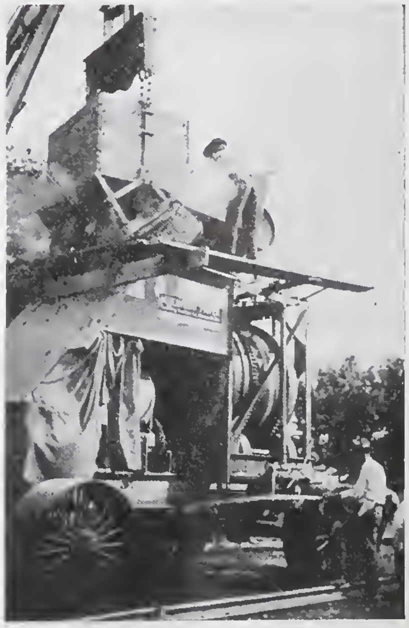
We are indebted to the Concrete Highway Magazine for the matter in this article.

August Record for Federal Aid Road Projects.—An increase for August compared with July in the total mileage of Federal aid project statements approved by the Secretary of Agriculture is shown in the latest report prepared by the Bureau of Public Roads of the Department of Agriculture, the total for August being 1,246.92 miles as against 1,168.66 miles for July. The 125 project statements approved in August involved improvement at an estimated total cost of $18,238,303, on which Federal aid in the amount of $7,171,794 was requested.


Central Proportioning Plant of G. P. Scharl on Branch County Road Job.


Bulk Cement Being Loaded in Aggregate Cars at Central Proportioning Plant.


Aggregate Cars Being Lifted Off Their Trucks Preparatory to Discharging into Mixer.


Contents of Aggregate Cars Discharged Directly into Mixer.

Should Contracts for Grading Upon Extensive Highway Improvements Be Awarded Separately?

The immense amount of work to be done in the highway field offers unprecedented inducement for contractors with sufficient capital and large organizations to bid for the larger highway offerings. The paving proper constitutes by far a larger portion of the money value of such contracts. It is the part for which special machinery and equipment may be employed that would make the hazards and delays that occur, when the work must be done by hand labor and teams, a practical minimum. Thus, if a contractor is awarded a contract for 20 to 50 miles of road, he installs material storage and handling equipment, tracks and power-hauling outfits so as to reduce to almost nil the human or animal muscle power required. This holds true so far as laying the pavement itself, but it is not so apparent that similar advantageous methods are afforded to handle the grading. Upon this part of the work a contractor secures few or no advantages merely because he is awarded a large mileage in a single contract. And so it comes about that some contractors desire to be relieved of the earth and other work preliminary to laying the pavement. An interesting discussion of this subject is given by Mr. A. N. Johnson, Consulting Highway Engineer, Portland Cement Association, in the September Successful Methods, from which the following is quoted:

In order to ascertain the opinions of the state highway engineers upon the question of handling grading contracts, a letter upon the subject was addressed to each. The replies received contain much that is pertinent and disclose so clearly what effect various conditions have upon the methods now pursued that a review of them will aid both engineers and contractors to approach this problem. Of the replies received there was about an equal division of opinion between letting a single contract to include grading and paving and letting separate contracts for each of these portions of the work.

The reasons generally advanced for letting single contracts for grading and paving are:

1. Avoidance of delays and conflicts that would arise between different contractors on the same work.
2. Less inconveniences sustained by the public due to the lesser mileage of roads that would be torn up.

Perhaps excerpts from two of the letters that bring out these points are sufficient. Col. W. D. Uhler, Chief Engineer of the Pennsylvania State Highway Department, states that:

> In letting separate grading contracts it means that the paving contractors cannot go on with their work until the entire grading is cleaned up, whereas under the present method, by the time the average contractor completes his grading on the job, the paving is from 50 to 75 per cent completed.
>
> You can plainly see that there would be a great loss of time were we to follow this practice. Our people want the roads and are willing to pay a fair price for them.
>
> As far as a scarcity of contractors is concerned, we have not experienced this condition, as we have been able to let everything advertised up to the present time at what we consider a fair price to both the state and the contractors. I think this is plainly evidenced by the large program which we have under way, being far greater than anything undertaken by any other states up to the present time.

The following comment is made by Clifford Older, Chief Engineer of the Illinois State Highway Department:

> In regard to the awarding of contracts for the grading of country road work separate from the pavement proper, doubt if we would secure much better competition under such a division. I realize there are a number of contractors who do not care to do the culvert or earth work in connection with pavement construction; however, there are a large number of small contractors who do not care to do the pavement work and are always desirous of subletting the earth work from contractors who take the entire work.
>
> There seems to be more or less confusion where two or more contractors have contracts for a specific piece of road improvement, as very frequently the grading or culvert contractor delays the pavement contractor. In many cases we find that it is much more convenient to build the side road culverts after the grading is completed and the pavement laid or at the same time the pavement is being laid.
>
> I believe that with the mechanical devices which are being perfected for grading, there will be less objection every year raised by contractors on account of the grading work. When the grading can be done by machinery, we believe it will prove to be more economical and more satisfactory to all concerned for a single contractor to take both the earth work and the pavement construction.

The last paragraph of Mr. Older's letter is significant as it points the way to a practical solution of much of the difficulty some contractors experience with grading. Small tractors have successfully taken the place of teams for scraper and wheeler work. This constitutes a very large percentage of all grading for highways. There are to be sure some instances, particularly in hilly and mountainous districts where comparatively heavy work is encountered, admitting the use of steam shovels. But, these may be considered as exceptional and aside from the prevailing conditions which are here discussed.

The state highway departments which express themselves in favor of single contracts for grading and paving are Maine, Massachusetts, Connecticut, Rhode Island, New York, Maryland, Nebraska, Minnesota, Tennessee, Montana, Utah, New Mexico, Oklahoma and Texas. The departments of Oklahoma, Maryland, and Texas each make the suggestion that contracts be so drawn that the general contractor is not only permitted but encouraged to sublet the grading. This opinion is well summed up in a letter received from J. N. Mackall, Chief Engineer of the Maryland Road Commission.

> What I believe would be productive of the best results would be to specify that the grading and drainage work could be sublet to other contractors and to encourage rather than discourage, as is done at present, the matter of subletting a portion of the work. If the work were sublet we would then have a general contractor to hold responsible for its prosecution, and there would be no claim on the commission for additional compensation due to extra work brought about by lack of cooperation

The arguments presented in favor of separate contracts for grading and paving are:

1. Allows fills to settle before paving is placed
2. Better prices can often be obtained with separate contracts.
3. Will make available local contractors equipped to do only grading.

Among the replies that expressed approval of separate contracts a considerable number did so qualifiedly, believing there are also advantages for letting combined contracts. Such expression of opinion was received from the departments of New Hampshire, New Jersey, Wyoming, Kentucky, South Carolina, Indiana, Missouri, Kansas, South Dakota, Idaho, Nevada and Oregon; while the departments of Delaware, Michigan, Iowa, Alabama, Arizona and Washington are more positive in their recommendation for separate contracts for grading and paving. Frank F Rogers, State Highway Commissioner of Michigan, states these arguments concisely.

> I wish to advise that this department is heartily in favor of letting contracts for the grading of roads separately from the paving. We prefer wherever possible to let grading contracts early in the season where it is possible to finish them, and let the grade settle through the winter, then the following spring place the pavement
>
> At the present time we have about half a dozen such [illegible] and I do not think we will be subjected to any criticism for proceeding along such lines. We surely get a better pavement in the long run.
>
> I am also of the impression that most paving contractors favor such a procedure. In many cases grading is the longest part of a contract in point of time. Many contractors have advised me that they prefer to take straight paving contracts where the grading has already been completed and only fine work on the subgrade and shoulders remains to be done.
>
> I might say that we are soon to undertake the construction of the balance of the road between Ann Arbor and Jackson on the Detroit-Chicago Paved Way, amounting to about 25 miles [illegible]. We intend to let separate grading contracts this fall for the grading and drainage structures. The grading on this road is extremely heavy, and I believe it is of the utmost importance that the grade be allowed to settle through one winter, if possible.

It is evident that there is a considerable difference of opinion. But from the somewhat conflicting data there are to be discerned certain facts that may be presented.

First, the problem has arisen because of essentially changed conditions. These are brought about by the desire on the part of the public to have completed, in the shortest time possible, extensive highway improvements, and, as an evidence of the sincerity of such desire, have voted bond issues of sufficient magnitude to complete, not only a system of improved highways for a county but for an entire state.

Those states not now confronted with such conditions (though from present indications these will soon be in the minority), do not have this problem for immediate solution. But there are a number of states and many counties now facing the construction, in the next few years, of an extraordinary large mileage of modern highways. The engineers and contractors in charge of these undertakings will have to meet the problem of handing the gradings so as to obtain the best results.

Needless to state there probably is no one general method of procedure which will be found to answer all of the varied conditions that must be fulfilled. But some of the factors that should be considered may be pointed out.

It must be evident that past experiences based upon a number of small contracts, scattered over a whole state, can scarcely be a sufficient guide by which to handle work involving hundreds of miles of improvements in long continuous stretches.

Whether the grading and paving are let separately or not a great advantage is gained if the fills can be made and allowed to settle over the winter before laying the pavement. There must of necessity be some added inconvenience temporarily experienced by the public but which can be overcome in no small degree by carefully planned detours, and the construction of temporary side roads.

The use of machinery, particularly of small tractors, to take the place of teams for road grading may offer some relief to contractrs who are ready to take large contracts but are fearful as to how they can handle the grading if they are obliged to rely upon the customary methods of the past.

It is essential that the amount of work awarded in a single contract be large enough to attract contractors with large organizations and sufficient capital to install the mechanical equipment necessary for rapid construction. And if contractors with such qualifications are be attracted to the work a greater latitude should be allowed them in handling subcontracts. The general contractor should have the opportunity to plan the work so as to be not only of an advantage to himself but so as to obtain the best results for the public.

$300,000,000 Expended in 1918 on Rural Roads and Bridges.—Cash expenditures on rural roads and bridges of the United States in 1918 amounted to $286,098,193, according to complete reports from 44 states to the U. S. Bureau of Public Roads. In addition the value of statute and convict labor on this work probably amonnted to $14,000,000, making the grand total expenditure for the year $300,000,000. This total is made up of the actual expenditures for such items as labor, materials, supervision and administration directly connected with the construction, improvement, and upkeep of our public roads and bridges outside the limits of incorporated towns and cities, and does not include any item for sinking fund payments or redemption and interest on road and bridge bonds. The total approximate cash expenditures for various years according to figures of the Bureau of Public Roads, have been as follows:

1904	$ 59,427,180	1917	$279,915,332
1914	240,263,781	1918	286,098,193
1916	272,631,429		

$558,000,000 of State Bond Issues for Roads.—State highway bonds totaling $224,800,000 were voted between Nov. 1, 1918, and July 1, 1919. In addition other states have been under definite provisions for submitting to vote between June 30, 1919, and Dec. 31, 1920, bond issues aggregating $314,000,000. The following states authorized bond issues between the first dates:

Illinois	$60,000,000	South Dakota	$4,500,000
Pennsylvania	50,000,000	Utah	4,000,000
Michigan	50,000,000	Wyoming	2,800,000
California	40,000,000	Nevada	1,000,000
Oregon	12,500,000		

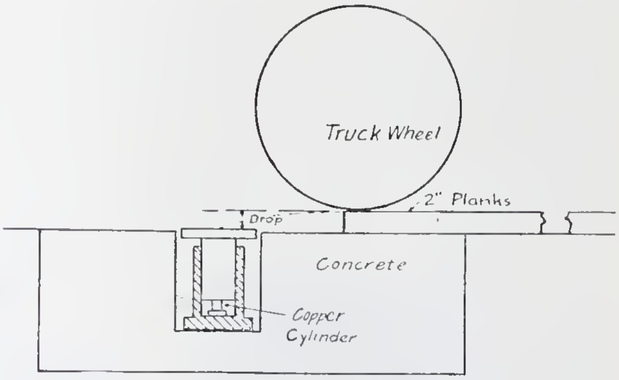
The bond issues to be voted on between June 30, 1919, and Dec. 31, 1920, are as follows:

Minnesota	$75,000,000	Montana	$15,000,000
Texas	75,000,000	Maine	10,000,000
Missouri	60,000,000	Colorado	5,000,000
West Virginia	40,000,000	Idaho	2,000,000
Washington	30,000,000	New Mexico	2,000,000

Impact Tests of Auto Trucks on Roads

Realizing the destructive effect of heavily loaded auto trucks on highways and streets, and the demand for data on the design of road surfaces and foundations to withstand such heavy traffic, a series of experiments is being conducted by the Bureau of Public Roads at the Arlington Experimental Farm to determine the impact of auto trucks on roads. A preliminary report on these tests, prepared by E. B. Smith, Senior Assistant Testing Engineer, and J. T. Pauls, Highway Engineer, has recently been made public by the Bureau. The matter following is from this report.

Equipment Used in the Tests.—The apparatus used in these experiments consists of a heavy steel cylinder in which is fitted a plunger 4 in. in diameter and 8 in. long, similar in construction to a hydraulic jack. A hole is left in the bottom of the cylinder in order to prevent air cushioning under the plunger. On the top or head of the plunger there is securely fastened a heavy steel plate, on which the impact of the truck wheel is received. This whole apparatus is supported rigidly in a concrete box placed in the road in such a position that the height of the steel plate on top of the plunger may be made just flush with the road surface. The height of the upper surface of the plate can be varied by proper steel disks placed under the plunger. In order that the front wheel may pass over and not touch the steel plate on the plunger, a steel bridge is used which is automatically tripped by the front wheel in passing over it. This releases a catch and allows a weighted lever to pull the bridge clear from the apparatus, thus leaving the steel plate exposed and ready to receive the impact of the rear wheel. By slight variations this bridge may be used to allow the impact of the front wheel to be received and then protect the plate from the impact of the rear wheel. The approach to this impact apparatus is made of 2-in. planking about 20 ft. long and is so constructed that the height of the planks may be varied above the road surface to give various heights of drop, and also can be moved forward or backward to give the proper jumping distance from the jump-off point so that the wheel will strike the center of the plunger at all speeds.



Apparatus Used in Making Tests.

For recording the impact value a copper cylinder ½ in. in diameter by ½ in. long is placed under the plunger of the jack. The impact received on the plunger is transmitted to the copper cylinder, where it produces a corresponding permanent deformation. The copper cylinders for this investigation are prepared from pure copper bars and are carefully machined to dimensions. They are then annealed by heating for 30 minutes at a uniform temperature of 650° C. in a bath consisting of a mixture of 20 per cent potassium nitrate and 80 per cent sodium nitrate, followed by cooling slowly in the air at room temperature. This treatment anneals the copper very uniformly. The finished cylinders are tested for uniformity in a universal testing machine, under a pressure of 6,000 lb. total static load, five cylinders being taken from each heat-treated lot. Thus far the maximum variation from the mean deformation value has been only 1.3 per cent, and this is less than other experimental errors.

A 3-ton U. S. A. class B truck with solid rubber tires was used for these experiments. The weight of the truck empty is 11,400 lb.; weight on front wheels, 4,550 lb.; weight on rear wheels, 6,850 lb.; weight of unsprung rear parts, 3,675 lb. Deflection of rear spring under weight of body alone is

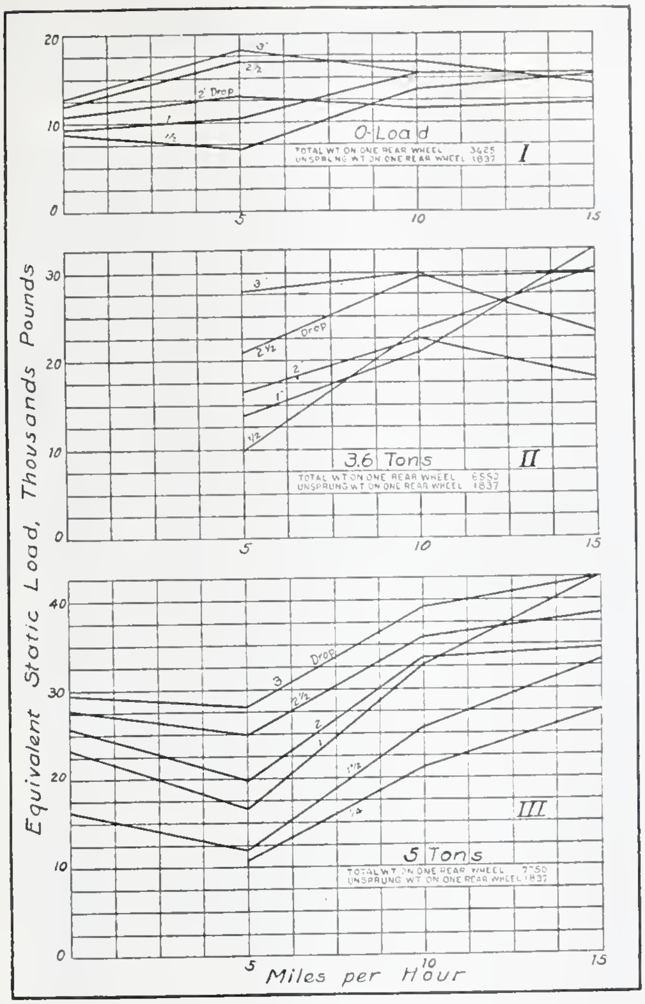


Fig. 1.—Results of Tests.

0.74 in. Weight on rear wheels when loaded with 7,200 lb. (3.6 tons) gravel is 13,100 lb.; deflection of rear spring, due to load and body, 2.62 in. Weight on rear wheels when loaded with 10,000 lb. (5 tons) gravel is 15,500 lb.; deflection of rear spring, due to load and body, 3.62 in. Diameter of rear wheels is 40 in., each fitted with two solid rubber tires, and each tire is 6 in. wide at the base next to the rim. Impact values were obtained only for the rear wheel, as it was the object to obtain values of the maximum impact of the truck. Rear springs were 57½ in. long, 4 in. wide, 6½ in. deep, with 17 leaves.

Conditions Under Which Tests Were Made.—The impact condition under which these tests were conducted was the simple falling of the truck wheel from one level to another at different speeds. Other conditions of impact will be investigated later. The magnitude of the impact is dependent upon: (1) height of drop, (2) weight of truck and load, (3) kind and condition of tires, (4) characteristics of springs and (5) speed of truck. Under these conditions, a series of tests were run, and the results are shown on the accompanying curves.

The impact, while measured by the shortening or compression of the copper cylinders, is shown in equivalent static load. That is, for each compression value of the copper the static load has been determined which would produce the same compression. All the curves are thus shown with the equivalent static load as ordinates. This may not be a perfect comparison of impact loads, as loads applied with impact will probably produce a much localized shattering effect which does not result from the application of an equivalent static load. For this reason, the present methods of comparing impacts by their equivalent static loads must be considered as tentative and subject to possible revision as the tests proceed.

Results of Tests.—The tests thus far give only the relative impact values, and do not attempt to demonstrate the destructive effect of these impacts. The destructive effect depends upon the road surface, the type of construction, and the foundation, and to arrive at the destructive effect of these impact forces, it is proposed in another series of experiments to subject certain road surfaces to these same impacts repeatedly until failure occurs. Machinery and apparatus for this purpose are now under construction.

The results as shown in curves I, II and III of Fig. 1, indicate a general tendency of increased impact toward the higher speeds, although the increment of increase is less as the speed increases. The relatively high impact values at zero speed, as shown in curve III, are explained by the fact that the results were obtained by dropping the wheel vertically upon the impact plunger, which resulted in the copper cylinder receiving, first, the impact, or kick of the spring, then an additional load an instant later from the falling of the truck body and load. Curves IV, V, and VI of Fig. 2 show the same data plotted with height of drop as abscissae. These curves indicate a general increase of impact with the increase of height of drop.

Influence of Truck Springs and Truck Power on Impact.—In conducting these experiments it was soon discovered that the action of the truck springs had a great influence on the impact results. When the wheel leaves the jump-off point the spring snaps open and produces a greater downward acceleration of the unsprung parts than that due to the action of gravity alone. If the compression of the spring is e and the height of the drop or jump-off point is d, then within the time of one vibration of the spring, the magnitude of the impact at the landing point will depend upon whether $d<e$, or $d=e$, or $d>e$. If the period of vibration is such that the spring has acquired its maximum acceleration, and at this instant also lands at the point of impact on the road surface, the impact value will be a maximum. The impact value will be a minimum when conditions are such that the spring is returning to its closed position and is at the point of maximum acceleration in this direction as the impact occurs. This explains why the impact values, as shown in the curves, do not consistently increase with the height of drop. The static loads equivalent to the impact values under the higher loads

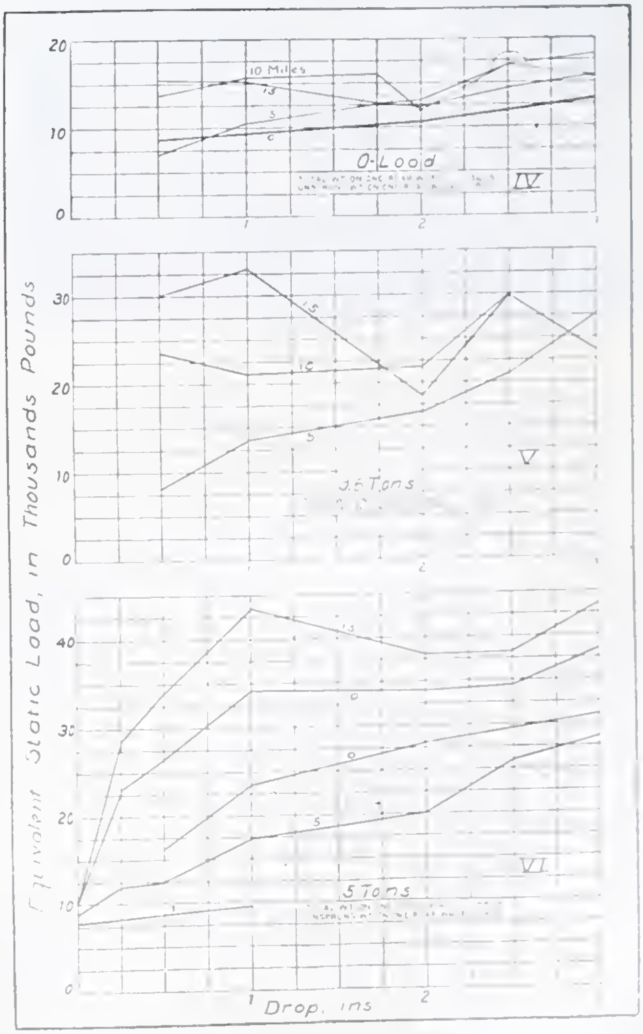


Fig. 2.—Results of Tests.

and drops are as much as five times larger than the total dead load.

It was also noticed during these tests that the impact was appreciably affected by the conditions of power on or off. That is, if the impact occurred when coasting it was less than when the power was being applied to the rear wheels. This difference amounted in some cases to as much as 30 per cent.

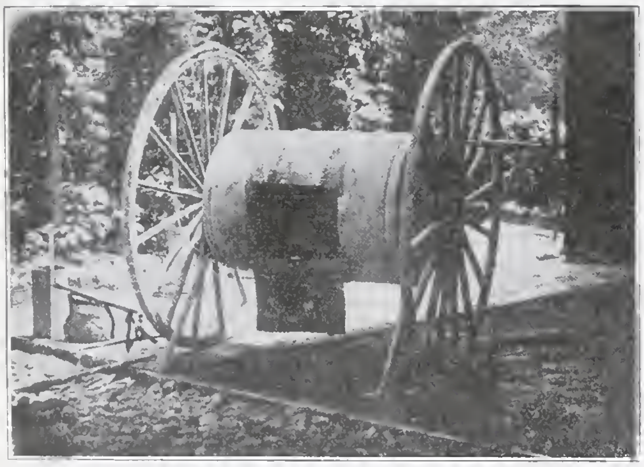
These results are presented at this time only for the purpose of showing the general tendency of impact values. It is the intention to enlarge upon this investigation to determine the relative effects of kinds of tires, loads, speeds, spring characteristics, and character of road obstructions and defects which produce impact values, and attempt to arrive at some definite conclusions as to the destructive effect of truck loads on different types of roads. It is hoped that this will ultimately result in definite road design data, and also lead to the establishment of rules and laws for the allowable loads and speeds of auto trucks.

Hand Operated Concrete Mixer Made from Oil Drum

By A. J. BECKWITH,
U. S. Lighthouse Service, 12th District, Milwaukee, Wis.

The cart mixer illustrated below was devised on a recent job and was found to be efficient and convenient for laying sidewalks and driveways.

The outfit has a capacity for a ⅓-bag batch. It consists of an old oil drum, mounted on two old buggy wheels about 4 ft. in diameter, having 1 pipe axle and pipe fittings. The hinged door is made to close down tightly when clamped, thereby preventing leakage of water. The interior of the drum is equipped with mixing blades properly arranged to throw the materials away from each end of the drum towards the center, as the drum revolves.



Portable Hand Operated Concrete Mixer.

Materials are handled but once. The cart is filled at the gravel and stone pile, churned and pushed to the spot where the concrete is to be placed. After loading, the wheels are braced by the handle of the cart on one side and by blocks or a plank on the other, to prevent motion of the cart as the drum is rotated by a hand crank. The hand crank, made up of pipes and fittings, has an extension pipe handle which slips freely into the outside crank handle, allowing it to be pushed in between the spokes of the wheel, thereby holding the drum in any desired position, and also allows the drum to revolve as the cart is in motion. If the haul is lengthy, mixing by pushing the cart will be found to work with surprising ease.

As the wheels are free and work independently of each other, the cart may be turned around in a space no greater than its own width.

Satisfactory results were obtained by washing the gravel free from clay and measuring accurately the proper amount of water and other materials. A slump test, as shown in illustration, was made for this day's pouring on a 1:2 mix using 9 per cent water by volume, securing a 9-in. slump after removing the 6-in. diameter, 12-in. long cylinder.

Present Day Bituminous Pavement Construction*

By R. KEITH COMPTON,
Chairman and Consulting Engineer, Paving Commission, City of Baltimore, Md.

Bituminous pavements will withstand and sustain a very heavy amount of traffic, preferably quick moving, light or medium loaded vehicles, such traffic, for instance, as prevails on many of our business streets. It is not claimed to be particularly adapted to dense, slow-moving, heavily loaded traffic. Some block pavements will outlast it under such conditions. It must have some traffic. If a bituminous pavement is laid on a street and traffic completely blocked off for several months, exposure to weather conditions will cause volatization or evaporation of the lighter oils, leaving the pavement hard, brittle and almost worthless. Its life requires some traffic in order to cause the kneading action necessary for it to retain these articles which are the very life and durability of the pavement itself.

Considerations in Selecting Type of Pavement.—Before deciding on the type of pavement to install a well informed engineer will take into consideration the extent, volume and character of traffic, the grade of the street, the width of the paved driveway between curbs, whether or not street railway tracks exist, character of the section to be served, whether business or residential, whether noise is a factor, and it generally is, and whether or not the street is in close proximity to a water front, as bituminous pavements will not withstand moisture. They must have occasion in which they can fully dry out. This will not be the case on a water front street because the moisture will come up through the concrete and deteriorate the pavement from its under side, effecting first the binder and then the top.

It is not claimed that sheet asphalt, which is a bituminous pavement of fine aggregate, is suitable for excessive grades. A grade may be excessive under certain traffic, but not under other traffic. Generally speaking, 6 per cent is the maximum grade for sheet asphalt on a heavy traffic street. On lighter traffic streets it has been laid with great success on grades up to and including 12 per cent. When excessive grades are encountered it is well to use a bituminous type of caorse aggregate such as bitulithic or asphaltic concrete. It is a well established fact that bituminous pavements are most slippery on light grades during bad weather when the pavement is covered with a thin film of slimy mud with insufficient rain water and grade to make it self-cleansing. This same condition does not exist on grades 3 per cent and over.

The pavement is no stronger than its base, therefore, great care must be exercised in deciding upon its character and thickness, depending mostly on the character and volume of traffic, but largely on the character of the sub-grade. Various kinds of base or foundation have been used; old macadam, cobble, brick and granite block have been resurfaced, using the old pavement as a foundation. Practical experience has proven that this is not first class construction although it has been followed with sucess in many instances. Its success depends entirely on conditions of the old pavement when the new top is installed and extreme care must be used in all phases of this construction.

Bituminous Surfaces on Old Pavements.—Assuming that one decides to resurface an old cobble or block pavement, he proceeds to notify all public service corporations and city departments to install their construction before paving operations are started. After they are through it frequently happens that very little is left of the original pavement. In other words, that which you had intended to use as a foundation has been practically destroyed and it cannot be replaced in its original condition. In the meantime your contract has been awarded on that basis and there is nothing for you to do but to proceed. An ever increasing volume of traffic attracted to the new pavement soon breaks through the foundation and the topping starts to disintegrate.

Assuming that the old pavement remains in its orignal condition, its contour will probably not conform to the contour which is desired for the new pavement and the difference has to be made up, probably a half inch in one quarter, several inches in the center and more or less on the other quarter. As there is not sufficient room for concrete, it is concluded to make it up with the binder. This means an excessive amount of binder, probably lack of compression, resulting in a wavy, poor surface, which may not develop at first, but undoubtedly will later under traffic. While this practice is not condemned, it is desirable to call attention to defects which may develop unless extreme care is used not only in inspecting the old pavement, but also great care must be used in looking after the details of construction when the new pavement is laid.

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*From a paper presented Aug. 28 before the convention of the League of Third Class Cities of Pennsylvania.

When the traffic is light as on state roads where they may not be main arteries of traffic and on some residential streets, old macadam has proven to be a suitable foundation for bituminous pavements, but the same precautions must be taken as that outlined for cobble and block foundations. The most desirable foundation for a pavement is concrete from 4 to 8 in. in thickness, depending on the factors named, generally 6 in. and of a 1-3 6 mix. The sub-grade should be thoroughly drained and compacted before the foundation is laid.

Central Mixing Plants.—Central mixing plants for extensive paving operations are now coming into vogue in large municipalities, thus avoiding congestion on the street in the storage of immense quantities of stone, gravel and sand, and hindrance to traffic, accidents, etc., and in case of storms or heavy rains much loss of lighter materials. The material is mixed at the central plant under the supervision of an inspector, transferred to the street in trucks and then handled very much the same way physically as the asphalitic material, but always under the supervision of an inspector on the street. Experience so far seems to indicate that this plan can be worked successfully provided the haul is not too long, say not exceeding 20 minutes. In this case sand and some loam is preferred to the absolutely clean sand because the latter is apt to cause a separation of materials in transit. This plan is at present working in a very systematic and practical way and as it is extended improvements will be made, so that in course of time streets can be improved in a congested section without so much interference, burden and inconvenience to traffic and the general public.

Inspection Important.—We must emphasize the importance in the construction of bituminous pavements of strict plant, laboratory and street inspection. Street inspectors should cover not only hot materials, but the concrete base and all other items as well. The street inspector must see that the concrete, if mixed on the street, is of the proper proportions, that the proper size stone, character of sand, etc., is used.

Regarding inspection of hot material the following plan in vogue in many of the large municipalities is outlined, and it has been found to work in a most satisfactory manner:

An adjunct of the municipal laboratory is established, known as the asphalt division, in charge of a chief asphalt inspector with sufficient sub-inspectors to cover all asphalt plants. This division also looks after the inspection of other materials such as stone, sand and cement and finished concrete. Depending on whether the concrete is mixed at a central plant or on the street, the chief asphalt inspector visits the points of mixing and selects the sample of concrete as it comes out of the mixer. This is sent to the laboratory where under the following process the street inspection is checked up, and we can tell very closely whether or not he is following the mixture provided for in the specifications. A sample of concrete base is taken from the grade after it has been raked and tamped (about one 14-quart bucketful), but before it is set. This material is then washed and the aggregate separated by screens, the ¼ in. screen to remove the stone and the 10 mesh to remove the large particles. The remaining sand and cement is then dried and screened over a 100 mesh sieve and what material passes the 200 mesh is, after making calculation for amount of very fine sand which passes the 200 mesh, taken as cement. It is not claimed that this process is absolutely correct, but it very closely approximates the actual proportions being used. Then again, the specifications may provide for a compressive strength test on a cube of finished concrete where cement concrete is used as a wearing surface. This is also handled by the chief inspector, who selects the sample, cures the concrete under field conditions, makes the test in accordance with standard practice and reports results to main office.

At each asphalt plant is stationed an inspector, who is equipped with screens, balances, a penetration machine and thermometer to be used in testing the stone, sand, asphalt cements and temperatures of the finished mixtures. All incoming raw materials are tested by the inspector at the plant as received, except the asphalt and residiums, which are sampled and sent to the laboratory for analysis before they are used. Samples of the stone, sand and dust are also taken to the laboratory and tested. The inspector is given a mixture showing the percentage of stone, sand and asphaltic cement by which to turn out the binder mixture, also the penetration at which the binder cement is to be maintained, each kettle being tested before it is used.

The procedure for topping mixtures is as follows: After the sand has been tested the inspector is given a formula telling the mesh composition of the sand, the amount of sand limestone dust and asphalt cement to be used, also the penetration of the asphalt cement. These instructions are received from the chief asphalt inspector. Each plant is visited at least once a day by the chief asphalt inspector, who makes an inspection of the plant and materials being used and collects samples of the asphalt cements, finished mixtures and the inspector's reports. These samples are taken to the laboratory, the asphalt cements being checked and the mixtures analyzed and any irregularities noted and the plant inspector immediately notified of same. The chief asphalt inspector during the day visits each street on which any material is being laid and takes samples, which are tested, and if found deviating from the mixture set, the inspector is at once notified of it and the trouble remedied.

When the mixtures arrive on the work they are tested for temperature by the street inspector, who oversees the laying of the binder and surface mixtures, seeing that the surface gets the proper amount of rolling and that the binder and wearing course are of the required thickness. The street inspector at the finish of each day's work sends a post-card to the laboratory showing the number of loads and batches of material received on the work, and also the yardage of material laid. These figures are checked against the reports of the plant inspector, the yardage per batch obtained and a report of same made to the principal assistant engineer and any irregularities noted and corrected. A record is on file at the main office and at the laboratory, of the cubical contents of the mixing box at each plant. A standard is set of how many square yards of a known thickness each batch should lay, after compression. In this manner we can tell whether or not the binder and topping laid on the previous day are of the required thickness as a check on the street inspector.

Gutters for Bituminous Paved Streets.—As a general rule brick gutters from 12 to 18 in. in width should be used on bituminous streets. They are absolutely necessary where there is any amount of surface drainage. Where all surface drainage has been eliminated they are still necessary on grades up to 2 per cent, but they are desirable on all bituminous streets, for two reasons. Gutters are for the purpose of collecting the water, and consequently the space next to the curb is nearly always damp, owing to collection of drainage, debris, etc. Furthermore, it is not always feasible to roll bituminous material in close proximity to the curb and the very existence of the gutters permits a more accurate cross section and contour and also permits the accomplishment of better compression and more expert handling of the roller.

Handling Hot Material on the Street.—Even though the hot material has been handled with expert care at the plant and transported to the street, great quantities of such material have given poor results, owing to defective handling on the street, such as poor raking and poor rolling. Too much care cannot be exercised in expert raking and rolling. Each load should be spread in a space separate and distinct from where it is dumped. One great difficulty in handling this material on the street is the practice of the spreaders or rakers standing in the material. This can be avoided by shoveling channels, commonly known by the men as "alleys" through the material for workmen to stand in; spreading the material in a space separate and distinct from that where it was deposited eliminates danger to a very great extent of any foreign matter such as blocks of wood and tin sometimes used by the careless drivers in order to close up crevices in the body of the hauling vehicle. Rolling material when it is too hot causes it to buckle and overlap. The use of too much water when rolling, which is very prevalent and a great [illegible], causes blisters. Both of these practices should be avoided. It is very difficult to obtain full compression in close proximity to hard surfaces whether by tamping or by rolling, so that it is desirable to keep the finish about ¼ in. high along gutters, liners, castings, etc., otherwise full compression, which is eventually obtained under traffic, will soon cause depressions.

In rolling, so many yards should be allowed per hour, per roller, approximately 250 for binder and 150 for wearing surface. With expert roller men this can be slightly exceeded, but it is important to keep the rollers continuously in operation as far as possible. It is preferable to start rolling with the lighter roller, then after the material has somewhat cooled off, follow with the heavy roller, using as the occasion may require, both rollers for the final finish. Hot smoothing irons may be a necessary evil, but should be avoided as far as possible, as they are exceedingly dangerous and attractive weapons in the hands of men who may carelessly and unnecessarily use them. It is necessary to use for a final covering a material to close up the pores, usually Portland cement. It should be spread and swept almost clean by skilled labor. It is poor practice and very wasteful to use too much of this material. One such man will save enough cement in an 8-hour day to more than pay his wages. Too freely used it causes an unsightly finish.

Standard Sheet Asphalt Construction.—Practically the same details of inspection enter into all classes of bituminous construction, although the construction of the bituminous portion of the pavement is not the same for all types. The standard sheet asphalt construction at the present time consists of 1½ in. binder and 1¼ in. top, laid on the foundation, while the standard bituminous pavement of coarse aggregate usually consists of 2 in. of bituminous material of the same mixture throughout laid directly on the concrete. All dimensions given are those obtained after full compression. The coarse aggregate type, being an open mixture, it is covered with what is known as a squeegee coat of bituminous cement, after which stone chips are applied. Moderately close binder is recommended for all pavements of the sheet asphalt type. The binder should contain a sufficient amount of asphaltic cement and fine material, otherwise it will break up under the vehicles transporting the top to its position on the street. Not more than one day's run of binder should be allowed and this should be swept clean before the topping is installed so as to secure a bond.

Coarse Mixture Bituminous Pavement.—The asphaltic content of coarse mixtures should be given more attention and kept within closer limits than will be necessary with sheet asphalt mixtures. This is because there is a clear relationship between the mineral aggregate and asphaltic cement in the coarse pavements than in the finer ones, and no great variation one way or the other in the amount of bitumen used is likely to cause trouble. Too much bitumen will cause the pavement to become soft, which means that it will be wavy and it will cause it to roll. Not sufficient bitumen will cause the pavement to be open, dry and to disintegrate.

When a bituminous pavement joins a block pavement, whether of brick or stone, a header must be used so as to keep both pavements in position, neither one being rigid in itself. The most common header used is of stone, such as old curbing, fairly well dressed with its surface showing between the two pavements. This, however, is unsightly and in time a hindrance to traffic. A desirable header is one of some hard substantial material such as stone or concrete, but countersunk, say, 2 in. below finished grade. This will hold the block pavement in position and at the same time allow the bituminous topping to be carried over flush with the surface of the block pavement, causing both pavements to maintain an even, smooth surface.

Road Mileage of the United States.—The present total mileage of public rural roads in the United States is 2,478,552, according to figures of the U. S. Bureau of Public Roads. Of this total approximately 299,175 miles or 12 per cent are surfaced. A large proportion of the mileage, however, is sand, clay, gravel or water bound macadam. During 1918 there was improved by the several state highway departments a total of 11,944 miles, of which about 7,000 consisted of grading, most of which was preparatory to later surfacing. In addition to this construction the several state highway departments also supervised the maintenance of 203,556 miles, most of which were main and trunk line highways.

Number of Horses in New York City.—A stable enumeration this year by the Sanitary Bureau of the Board of Health of New York showed 75,740 horses in the city. In 1917 there were 108,036.

Road Drainage and Foundations*

By GEO, HOGARTH,

Chief Engineer, Ontario Department of Highways.

In building any roadway, whether for light or heavy traffic, two of the most important points to be considered are drainage and foundations.

The stability of the entire road surface depends upon the foundation and the strength and life of the foundation depends largely upon the facilities provided for drainage. While proper attention may be given to the drainage of the surface of the road by giving the roadway sufficient crown to shed the water, the great importance of subsurface drainage may be entirely overlooked. There are, therefore, surface and subsurface methods of drainage and the very great importance of each must be realized and used to the fullest extent if we desire a permanent foundation.

A sound and enduring foundation cannot be secured on subsoil saturated with water, but a good foundation can be secured by the simple means of keeping the subsoil dry. If water is not excluded from the foundation it will sooner or later destroy the road surfacing, since no road ever built could escape destruction should the foundation become yielding and soft.

Importance of Proper Drainage.—The ordinary clays and earths form a naturally strong foundation when dry, but where the ground is wet and springy a good road cannot be constructed without proper subdrainage since when wet the earth loses its sustaining power and the surface formation goes to pieces. Where the subsoil is gravelly, underdrains will usually not be required, but where it is sandy, give close attention to the damp or wet spots and provide ample subdrainage.

It may be said that the whole problem of improvement and maintenance of ordinary country roads is one of drainage. Upon earth roads drainage is especially important because the material of the road surface is very susceptible to the action of water and so is more readily destroyed than are the surfaces of the better class of roads. An undrained earth roads offers a splendid opportunity to the frost, and a spring thaw may result in such a road being impassable for days or weeks. A road on a wet undrained bottom will always be troublesome and expensive to maintain, and it will be economical in the long run to go to considerable expense in making the drainage of the subsoil as perfect as possible.

There are three systems of drainage, namely: Underdrainage, side ditches and surface drainage.

Underdrainage will lower the water level in the soil and keep it at a safe distance from the foundations. This aids the action of the sun and wind, which tend to dry the surface of the road, but if the foundation, due to lack of underdrainage, is soft and spongy, the road will soon become a mass of mud.

Underdrainage, dries the ground quickly during the spring when otherwise a saturated condition of the soil would exist.

Underdrainage intercepts the subsurface flow of water beneath the crust of the road.

Some Points on Underdrainage.—In many cases it will be noticed that though the ground is dry, when it freezes in the fall, it is very wet and soggy in the spring when the frost comes out. The reason for this condition is that after the ground freezes, water rises slowly in the soil and if it is not drawn off by underdrainage it saturates the subsoil and rises further as the frost goes out. Underdrainage not only removes the water but reduces and will in many cases prevent the destructive heaving effects of frost.

The heaving and cracking of pavements may be entirely attributed to the freezing of water in the subgrade under the pavement. Underdrainage will greatly lessen the damage done in this way by the frost, but to prevent entirely such destructive action may be very difficult. It may be said that when underdraining a section of road known to have a wet subgrade it is well to provide a liberal number of drains. Too many cannot be laid. Particular attention to the underdrainage should be given at points on the road from 50 to 200 ft. or more down grade from the top of a hill or slope and particularly so if the roadway is in excavation. Water will usually filter out to the surface at such points and the entire skill of the roadbuilder will have to be exercised in locating subdrainage to prevent heaving and cracking. In all such cases do not curtail the underdrainage, but rather put in every foot of tile that can be placed.

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*Paper presented at the Canadian Good Roads Congress, May, 1919.

Wherever the underdrainage is provided be careful to provide proper grade and good outlet for the tile since poor results will come from the tile that are indifferently laid and improperly vented.

Tile drains furnish the usual means for subdrainage, but in some cases a blind drain may be used to good advantage. The construction of a blind drain is accomplished by opening a trench several feet deep along or across the road and afterwards filling the trench with stone. The depth, distance apart and location of such trenches will depend entirely upon the conditions encountered and the result desired. Careful attention to the subdrainage of the road is of great importance and money spent for such work is always a splendid investment.

Surface Drainage.—Side ditches for all country roads are essential. Their object is to receive the water from the surface of the travelled roadway and the grade of the ditch should be such that the water is carried rapidly to a good outlet. Such ditches also intercept and carry away water that would otherwise flow from the side hills upon the road. Side ditches need not be very deep; a depth of 2½ or 3½ ft. below the crown of the roadways will usually be found sufficient and the sides should be given a slope flat enough to prevent caving. In order to be effective, ditches should have as great a grade as possible, they should be well cleaned out and have free outlet in some creek or stream.

Surface drainage of the traveled portion of the road affects mainly the maintenance of the road and is accomplished by giving the road or pavement surface a crown which tends to shed the water to the side ditches. The slope of the crown should be sufficient to carry the water freely and quickly to the side ditch. The proper crown to use will vary with the nature of the roadway; when a good surface is maintained, a moderate rise will be found sufficient. For earth, clay or gravel roads a usual crown is 1 in. per foot, while for bituminous or concrete pavements ½ or ¼ in. per foot is ample.

Foundation.—While drainage is undoubtedly one of the first essentials of good highways, the foundation of a road is also of great importance and one of the first substantial advances in road building was made when the laying of a course of stone for the base of a road was adopted.

The foundation of a road should normally last a number of years while the cost of maintenance should be for replacing and renewing the wornout surface. Such conditions are difficult to obtain since the foundation of 4 in. of crushed stone today may be entirely inadequate tomorrow under more severe traffic. The heavy loads using highways today require an abundance of material in the foundation of the roads and if our work is to be enduring we must see to it that strong and sound foundations are provided.

Frequently the taxpayer may inquire as to why so much material is required in a road and a demand will be made for more surface with a smaller amount of stone hidden in the foundation. Such an inquiry loses weight when the same ratepayer states that a concrete road 6 in. thick is too heavy and his idea of a concrete road is a surface of concrete about an inch thick spread over the entire space between the fences.

Roads built only a few years ago are in many cases in poor condition or destroyed today because a shallow, weak foundation was provided. Improved roads naturally draw traffic and people will go many miles out of their way in order to travel over a section of good road. This fact should be given full consideration in designing a road and any traffic census made prior to reconstruction should be considerably increased in order to estimate the travel on the improved surface. A road is not rebuilt to provide only for present traffic but it is rebuilt to carry present traffic together with whatever vehicles may use it when improved and in some cases it may be found that the traffic on an improved road immediately after reconstruction is 10 or more times the original number of vehicles using the road.

Classes of Foundations.—The strength of the foundation of a road is greatly affected by the supporting power of the different soils and in order to obtain a road surface having a uniform resistance, the thickness of the crust will need to be varied. A greater depth of foundation will be required on soft clay than on gravel and for soils of intermediate strength a varying thickness will be required. Soils of poor supporting power will carry safely a load of about [illegible] lb. per square foot while gravel subsoil is safe under a loading of about 3,000 lb. per square foot.

Many kinds of foundation courses are available in the construction of roads, such as crushed stone, screened gravel pit gravel, field stone, quarry stone or Telford. Before placing a foundation course the subgrade should be properly rolled in order to solidify the surface and prevent the material of the foundation being forced into the soil. This point is as important with a gravel road as it is with more permanent types of construction. A smaller amount of crushed stone or gravel will be required to build the foundation of a road on a consolidated subgrade and the rolling and compacting of the subgrade before placing the foundation is therefore an economy. A compacted subgrade also enables the foundation of the road to better withstand the effects of heavy traffic, whereas a soft and yielding subgrade tends to cause a sinkage of the foundation with consequent hollows and holes in the road.

Crushed stone where used as a foundation for a macadam road should be not less than 6 in. in thickness when compacted and the size stone will usually be about that passing a 2½-in. ring.

Screened gravel of 1 in. to 3 in. size may be used in place of crushed stone and when placed in the road a filler containing some clay or loam should be spread in order to thoroughly consolidate the stones.

Such gravel does not interlock as crushed stone does and a thicker foundation course of gravel is therefore required.

Field stone used for a foundation may be laid in one course from 6 in. to 12 in. in depth and the inequalities between the stones filled with coarse gravel or crushed stone. The depth of the course should in all cases be suited to the average size of field stone available as it is not economical to break them to a definite size. A variation of an inch or so in the size of the stone is of no consequence since the surface stone will serve to even up all inequalities.

The Telford base may be composed of quarry stone which has been broken to size with a stone hammer. Such foundations have given good satisfaction when used but the cost of hand placing the stones seems to have outweighed the advantages of this type of construction.

In conclusion it may be said that the adequate drainage of a road is the first requisite to permanence and if we add to proper drainage a sound foundation, the cost of maintaining the surface of the road will be greatly lessened. Drainage and foundations are two very essential details of road construction and close attention to these points when designing and constructing a road will lead to better, more durable and more satisfactory roads.

Pneumatic Tires May Revolutionize Truck Design

The great increase in the use of giant pneumatic tires on trucks of 2 tons capacity and over may eventually result in a complete revolution in the design of truck chassis intended to be employed with such tires instead of solids. It seems apparent that a great reduction in weight can be secured due to the better cushioning effect of pneumatics, as compared with solids. Up to the present time, little has been done along this line. When a truck owner wants to use pneumatics instead of solids, the truck maker generally furnishes the identical chassis as ordinarily fitted with solids and tells the owner that he will be able to secure greater speeds with the same degree of safety as when solids are used. It will not be long before the truck owner will be dissatisfied with such a method and demand a real pneumatic-tired chassis.

The result of the experiment in running large pneumatic-tired trucks overland between Akron and Boston for two years seem to indicate that an ordinary 3-ton chassis designed for use with solid tires can safely carry 5 tons when mounted on pneumatics. After further investigation, it is even possible that several hundred additional pounds may be shaved off the 3-ton chassis weight when used to carry 5 tons on pneumatics. It is also evident that engines of greater power must be installed in order to permit the greater speeds made possible by the use of pneumatics to be secured.—The Commercial Vehicle.

Proposed Schedule of Salaries for Engineers in State Highway Service

A proposed salary schedule for state highway engineers has been prepared by the American Association of Engineers' Committee on "Salaries of Engineers in Public Service." In appointing the committee last June, the Board of Directors gave it authority to add to its personnel, with the approval of the President, representatives of the several branches of public service engineers in order that the schedules as finally adopted should be not only harmonious with reference to each other, but that they should be generally accepted as stating the value of engineering service to the public, hence what it should pay for such service. In discussing the schedules engineers should therefore bear in mind that the endeavor of the committee is not to standardize and classify engineering service, but to price this service.

The Committee on Salaries of Engineers in Public Service consists of S. C. Hadden, editor of "Municipal and County Engineering," J. H. Prior, consulting engineer on public utilities, Chicago; A. R. Hirst, state highway engineer, Wisconsin; F. H. Newell, president of the association, and A. N. Johnson, chairman, consulting highway engineer of the Portland Cement Association. Preliminary to drafting the schedule for highway engineers, the following were invited to serve as corresponding members of the committee: Thos. H. McDonald, chief of the U. S. Bureau of Public Roads; W. L. Basset, Bureau of Municipal Research, New York; Col. W. D. Uhler, chief engineer, Pennsylvania, State Highway Department; A. B. Fletcher, state highway engineer of California; A. W. Dean, chief engineer, Massachusetts Highway Commission, and Clifford Older, chief engineer Illinois State Highway Department.

The proposed schedule, discussion of which is invited by the committee preparatory to presenting it to the association for final adoption, is as follows:

Administrative and Executive Positions.

Chief Engineer	$8,000-15,000
In charge of all construction and maintenance work of the department, acting as chief executive officer.	
Engineer of Construction	6,000-10,000
In immediate charge of all construction work from time contracts are let. Assigned to state headquarters.	
Engineer of Maintenance	6,000-10,000
In charge of all maintenance work. Assigned to state headquarters.	
Engineer of Bridges	5,000- 8,000
In charge of preparation of specifications and designs for bridges, and in charge of construction of special bridges. Assigned to state headquarters.	
Office Engineer	5,000- 8,000
In general charge of preparation of plans and specifications for all construction work up to point of letting contracts. Assigned to state headquarters.	
Engineer of Tests	4,000- 7.000
In general charge of laboratory routine tests, investigations, material surveys and field inspection of materials.	
District Engineer	5.000- 8,000
In charge of all construction and maintenance work in a division or district of the state, generally including a number of counties. Assigned to division headquarters.	

Engineering Positions involving Some Administrative Duties in the Higher Grades.

Advisory and Consulting Engineer to the Chief Engineer	5,000-10,000
First Assistant Engineer, assigned to Construction Engineer at state headquarters	3,600- 5,000
In general charge of office work in connection with execution of contracts.	
First Assistant Engineer, assigned to Maintenance Engineer at state headquarters	3,600- 5,000
In general charge of office work in connection with maintenance.	
First Assistant Bridge Engineer, assigned to Engineer of Bridges at state headquarters	3,600- 5,000
In charge of bridge drafting room and responsible for bridge specifications and bridge designs.	
First Assistant Engineer, assigned to Division Headquarters	3,600- 5,000
In general charge of division headquarters office.	
Assistant Engineers, assigned to Construction Engineer at state headquarters	2,400- 4,000
Duties as assigned.	
Assistant Engineers, assigned to Maintenance Engineer at state headquarters	2,400- 4,000
Duties as assigned.	
Assistant Engineers, assigned to Bridge Engineers at state headquarters	2,400- 4,000
Acting as especially skilled draftsmen, designers and computers.	
Assistant Engineers, assigned to Office Engineer at state headquarters	2,400- 4,000
Preparing and checking specifications and plans as received from division offices. Work as assigned.	
Chief Chemist, assigned to Engineer of Tests at state headquarters	3,500- 5,000
In charge of the chemical work of the laboratory.	
Assistant Engineers, assigned to division headquarters.	
Some in charge of construction, others in charge of maintenance, both field and office work as assigned.	
Assistant Engineers, assigned to laboratory work	2,400- 4,000
Tests and investigations in laboratory, field examinations and reports on sources of materials as assigned.	
Assistant Chemists, assigned to laboratory	2,000- 4,000
Chief Draftsman, assigned to division headquarters	2,400- 4,000
In charge of division headquarters drafting room and the preparation of plans.	
Chiefs of Survey Parties	2,400- 4,000
In charge of surveys and relocations; during time spent in office, work on plans and computations as assigned.	

Inspectional Service.

Confidential Inspectors, assigned to Chief Engineer	4,000- 5,000
Report only to Chief Engineer on work of all character wherever it may be. Positions of peculiar responsibilities, represent the chief engineer.	
General Inspectors of Maintenance, assigned to state headquarters	2,400- 4,000
Inspectors of Bridge Construction, assigned to Bridge Engineer at state headquarters	2,400- 4,000
Inspecting construction of the larger bridges only. Work inside on bridge plans and design as assigned.	
Field Inspector of Materials, assigned to Engineer of Tests at state headquarters	2,400- 4,000
Inspection of materials in the field and at points of manufacture.	
Inspectors of Construction, assigned to Division Engineers at division headquarters	2,400- 3,000
Inspect construction, reporting to division engineers, or a number of inspectors may be under immediate charge of some assistant engineer to whom they make immediate reports.	
If inspecters are employed during working season only to receive, per month	250- 300
Inspectors working the year around are at division offices during winter on plans, estimates and computations, as assigned.	

Junior Engineering Positions, Concerned with Routine Work Only.

Engineering Draftsmen, computers, checkers, estimators, assigned to state headquarters	1,800- 2,400
Tracers, Computers, heckers, assigned to bridge engineer	1,800- 2,400
Engineer Draftsmen, assigned to division headquarters	1,800- 2,400
Preparation of plans, computations, estimates, checking.	
Instrument Men	1,800- 2,400
Transitmen and levelers.	
Those employed the year around work inside division offices, part of time on plans, computations and estimates.	
If employed by month during construction season only, they should receive, per month	200- 250
Rodmen and Chairman	1,200- 1,500
Laboratory Assistants	1,800- 2,400
Routine testing, laboratory records.	

All engineers working away from state or division headquarters to which they may be assigned are to receive traveling and subsistence expenses.

This schedule not to operate to reduce any salaries now existing.

City Managers to Meet at Indianapolis.—The 6th annual meeting of the City Managers' Association will be held at Indianapolis, Ind., Oct. 27-29. The National Association of Commercial Organization Secretaries is to be in session at the same city at that time and efforts will be made to arrange for at least one union session in order to cement more closely the cordial relations between city managers and chamber of commerce secretaries. H. G. Otis, 1812 Tribune Bldg., New York City, is executive secretary of the City Managers' Association.

Highways to Lower the High Cost of Living

By JOHN S. BEALL,
President, Armco Iron Culvert & Flume Manufacturers' Association.

To say that unimproved roads increase the cost of living is to give a reason without a remedy. Economists are raising their voices against waste and mismanagement, both of which undoubtedly add to the fast-mounting cost of everything we eat and wear. Today we hear that blame should be placed upon the middleman; yesterday the effect of the World War was proclaimed the reason for high prices; tomorrow we will hear that the high cost of everything is due to some other single cause. But, in my opinion, the high cost of living today is due to a combination of causes, no one of which is altogether to blame.

When we consider that following every great war, with its necessarily vast destruction of property and slowing up of production, prices rise and the cost of living consequently increases beyond the income of the average person, we must look behind the alleged causes which are today said to be making prices high, and get down to the fundamental causes which made living higher than it should have been before the great social and economic disturbance which resulted from the world conflict. In other words, we must find out what made living as high as it was before 1914.

People never kick about the price of a thing, if they can afford to buy it. It is only when the price of a commodity rises beyond the amount of money they can afford to pay for that commodity that we hear cries of profiteering and witness social unrest, such as is sweeping the country today.

The last 50 years have seen the growth of huge cities in the Central West, and West, and a consequent concentration of population in these cities. Where eggs were 6 ct. a dozen 50 years ago they now cost 56 ct. Where they were eaten fresh from the barn yard 50 years ago, they are today transported to cities, placed in cold storage and later, months later, sold to the consumer when he has 56 ct. which he can afford to devote to the purchase of this food. The farmer who once "drove to town" with his load of eggs, has now been pushed, by the growth of cities, many miles from the city markets and depends upon the railroads to carry his product to where he can receive a high enough price to allow him to carry on his farming business and supply himself and his family with the necessities of life—necessities he cannot himself produce, if he is to maintain his farm at its maximum production.

Just as the railroad seemed to make the farmer independent of the highway, so is the motor truck developing to make the producer of foodstuffs independent of the railroad. The railroad, however, is an organization owning the rolling stock and tracks over which the cars are operated, while the motor truck owner is often an independent unit, operating over a road controlled by the money of every road-bond buyer and taxpayer in his community, and the communities through which he must pass if he transports his product by motor truck to market.

It has been said that the cost of food has not been greatly lowered in eastern cities where farmers, either single or co-operating, transport their products by truck from farm to market. This is true where the farmer sells to the wholesaler, and the wholesaler sells to the retailer who in turn sells to the customer, who is the ultimate consumer. By this method only the high freight and express rates of the railroad are eliminated, and these are replaced by the cost of motor transport.

But where municipal retail markets have been established, the cost of food products has been materially lowered. The farmer drives in with his produce and sells direct to the consumer. Many cities are developing these municipal markets, where those who cannot afford to pay the high prices charged by the retailer, and made necessary by the number of hands through which the products pass, can purchase on the cash and carry plan.

The recent Government seizure of food products, under the war-time food laws, has turned the attention of the public toward cold storage methods. The food hoarder is threatened with jail; the food controller or "packer" is being condemned, and drastic laws are being advocated to regulate monopoly and the withholding of products from the market by storing them.

Until production gets back to normal, and supply and demand are to some extent regulated by the completion of the Reconstruction Period through which we are now passing, we cannot hope for greatly lowered prices. But we can turn our minds today toward the construction of the necessary works which the present high prices and unstable conditions have made us realize played a big part in bringing about the situation which now confronts us. The Federal Government and the states have realized this and we see evidence of their activity in the great, road-building plans now in operation or under consideration; the vast amount of money set aside for road construction purposes, and the active advocation of suitable legislation to bring about a nation-wide system of improved highways.

Conspicuous among the Highway Legislation before Congress, is a bill now pending in the United States Senate, which was introduced by Senator Townsend, chairman of the Committee on Post Offices and Post Roads.

It is proposed in this measure to create a vast system of highways under Federal control and maintenance. This system will embrace not less than two per cent or more than five per cent of the mileage in actual use in each state in the Union.

What will such a system, when completed, mean to the people of the United States? For one thing, and it is fundamental, which has long been neglected, and never properly considered, it will bring our food-producing areas nearer to our manufacturing centers and mean that the vast numbers of people engaged in manufacturing will, with proper legislation designed to bring about the condition, pay less for the food they eat, and for everything that is produced by nature to feed the wheels of industry.

The man who lives on the highway, and produces food products along the highway, will benefit by highway improvement, because the cost to him of transporting the product he raises to the local market will be less. Or, if he transports his product direct to the consumer in the city via the Municipal Market or direct to the home, he will have the benefit of the profit now paid to the railroad company, the middleman, the cold storage plant and the retailer. In this way the farmer can get much more for his products than he receives at the present time, and still sell them to the public at an even lower price than he did before the war.

For this brief survey it is clear that the improvement of roads should be the concern of every person, whether he be laborer, farmer, merchant, banker, doctor, lawyer or otherwise, living either in the city or in the country. The improvement of highways is a definite, fundamental step toward decreasing the high cost of living. It is something which needs no investigation to prove necessary. Let us put our shoulder to the wheel and roll the mud holes into better roads.

Constructing 31-ft Concrete Road in Two Sections. In order to facilitate striking off the concrete and to avoid the use of a heavy template, a 31-ft. concrete road in Wilson Township, Penn., was struck off in two sections. A rolled steel template 16 ft. long and 8 in. wide, with a crown of $\frac{1}{4}$ in. to the foot was used. One end of the template rested on the side form and the other end, which was equipped with 8 in. vertical and horizontal arms, rode on a steel anglebar supported on two steel pins, 27 by $1\frac{1}{4}$ in., threaded 6 in. at the top and driven into the subgrade. A stake was set on grade about 25 ft. ahead of the finished work and a cord stretched from this stake back to the finished pavement The pins were then driven so that their tops were about 1 or 2 in. above the cord. A nut was screwed onto each pin and the anglebar placed so that the bottom leg rested on the nut. The anglebar was adjusted so that it was flush with the string by means of the nut and then held firmly in place by another nut. The anglebars were made in 6-ft. lengths so as to be adjusted easily for grade and three lengths were set up at a time. When the concrete had been placed and struck off on one side of the pavement, the template was moved to the other side, taking care that the same end was placed on the anglebar. It was necessary for one of the men when the second half of the pavement was being struck off, to stand on that part previously finished but it was found that with the proper consistency, a plank laid on the concrete for the men to stand upon made only a slight depression which was easily filled as soon as the anglebar was moved ahead. Holes left in the pavement by the withdrawal of the pins were properly filled. Finishing was done with a roller and belt.

New Adjustable Leaning Wheel Road Grader

A new adjustable leaning wheel road grader, embodying some new features, has just been placed on the market by J. D. Adams & Co., Indianapolis, Ind. The machine is known as the Road King No. 12. It has a 12-ft. blade length, a wheel base of 17 ft. 1 in., and a wheel tread of 5 ft. 7 in. in front, and 8 ft. 6 in. in rear. The rear axle is side shiftable 40 in. from right to left. The machine's weight complete is 6,740 lb., and the tractor power required to successfully pull it is stated to vary from 25 to 40 draw-bar horsepower, depending upon the amount of dirt to be moved. A time-saving ditch sloping attachment for use with the new machine also has been brought out by the company. This special attachment slopes and finishes outside ditch banks and makes flat bottom in ditch approximately 1 ft. wide or wider. It is attached to the right end of the blade, and to the front end of the draw-bar by means of brackets that are bolted on and it is readily detached without removing the brackets.

Road King No. 12.

Method of Laying Out Additional Widths for Road Curves

A method of laying out additional widths on curves which has just been put in use by the Minnesota State Highway Department is described by Mr. Edward H. Steele, Assistant Construction Engineer of the Department, in a recent issue of Successful Methods.

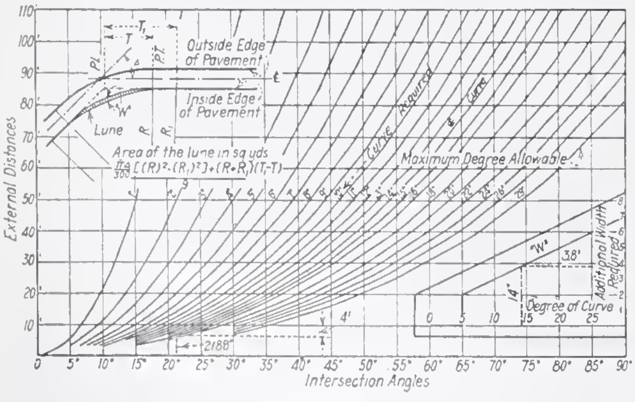

Chart Used by Minnesota Highway Department for Widening Road Curves.

The layout of a sample curve is shown in the figure. To make the problem definite, it is assumed that the intersection angle is 21° 50′, and the center line curve has been designed as a 14° curve.

In the lower right-hand corner of the chart is a graph showing the required additional width for various degrees of curvature. A 14° curve requires 3.8 ft. additional width. It may be taken as 4 ft. (the nearest even foot) for ease in computation. The degree of curvature which will give the required extra width is secured from the graphs of external distances for various degrees of curve. Find the intersection of the 14° curve line with the 21° 50′ (21.88°) ordinate. From this point measure vertically upward 4 ft. and read off the nearest degree of curve, which is 10°. This is the required curve.

In computing the area of this additional width, use the formula given in the chart. The precision of the tangent distances is the controlling factor in the formula used, and computation should be carried to three decimal places.

Hand Patrol Street Sweeping at Los Angeles.—The business district of Los Angeles, Cal., is patrolled by hand sweepers from 6 a. m. to 6 p. m., while the semi-business, industrial and residence districts are given less service. The minimum area cared for per man is 4,422 sq. yd. on the main streets in the downtown district, while the maximum area cared for per man is 52,574 sq. yd. The average area cared for per man is 34,441 sq. yd., according to the last annual report of A. C. Hansen, City Engineer, for the year ending June 30, 1918. Each patrolman is equipped with a 24-in. bass broom, and wheel scraper, and reports the beginning of each work day at a conveniently located tool box. The sweepings are collected by pick-up men equipped with a team and dump wagon, or a 2-ton motor truck with a 4-yd. dump bed. The sweepings are delivered to dumping stations of local fertilizer companies, who dispose of it in the agricultural districts of the county. During the year 1917-18 the city has received a consideration of $531 per month from this source.

Personals

Charles Moore has resigned as borough engineer of West Hazleton, Pa.

Winfield F. Courts has been appointed highway engineer of the city of Baltimore, Md.

Alfred A. Moreland has been appointed commissioner of street cleaning of Baltimore, Md.

Edward Von Geldern, county surveyor of Sutter County, California, has been appointed county engineer.

T. W. Webb of Dallas, Tex., has been appointed engineer of the material division of the state highway department of Texas.

S. E. Washburn, formerly city engineer of Montgomery, Ala., has been appointed county land surveyor of Mongomery County.

W. B. Covington of Rockingham, N. C., has been appointed county superintendent of roads in Robeson County, North Carolina.

J. W. Benjamin of Cuero, Tex., has been appointed division engineer of district No. 4 with headquarters at Amarillo, Tex., by the Texas state highway commission.

W. F. Cocke, for 3 years state highway commissioner of Florida, has accepted the position of assistant state highway commissioner of Virginia, and will enter on his duties about Oct. 1.

H. B. Aikin, formerly connected with the state highway department of Kentucky, has been appointed to the staff of the civil engineering department of the University of Tennessee.

Prof. B. L. Wolfe, a member of the University of Kansas engineering faculty, has been appointed county engineer of Douglas County, Kansas. Prof. Wolfe will continue his work at the university.

Maj. Charles A. Browne of Orlando, Fla., who has been for the past several months divisional engineer for the state road department of Florida, has been appointed state highway engineer, succeeding William F. Cocke, resigned.

Frank P. McKibben has resigned as professor of civil engineering at Lehigh University and as vice-president of People's Trust Co., Bethlehem, Pa., to assume charge of the Civil Engineering Department at Union College. He will continue his consulting engineering practice with headquarters at Schenectady, N. Y.

Industrial Notes

The Chicago Pneumatic Tool Co. on Oct. 1st removed its Birmingham office from 801 Brown Marx Bldg. to 1925 Fifth Ave., North, where a service station with a complete stock of pneumatic tools, electric tools, air compressors, oil engines, rock drills and repair parts is maintained.

The Hazard Manufacturing Co., Wilkes-Barre, Pa., has placed William S. Hart in charge of its Chicago sales office and warehouse, with the title of district manager, effective Oct. 1. Albert W. Gabriel, who has been district manager for a number of years, has resigned to embark in another line of business. Mr. Hart was for several years asisstant district manager of the Hazard Pittsburgh branch, and during the last two years has been assistnt general superintendent at the factory.

Work has been begun on a new factory building being erected by the J. D. Adams & Co., Indianapolis, Ind., manufacturers of adjustable leaning wheel graders and other road building and maintaining equipment. The new building, which is to be 210 ft. by 162 ft., of 1-story concrete construction, adds some 34,000 sq. ft. to their already large factory.

The Chain Belt Co., Milwaukee, Wis., the stockholders of which recently voted to increase the authorized stock from $1,000,000 to $2,800,000, has started on a building program that eventually will mean the evacuation of the present plant at 16th and Park Sts., and its removal to a new 23-acre site at 39th and Orchard Sts. Building operations are to progress by departmental units as rapidly as business conditions, removal difficulties and other considerations will permit, but the entire undertaking will, no doubt, be a matter of but a short time. Ground has just been broken for the first unit, a steel and brick structure 316x150 ft., to house the concrete mixer assembling department. The plans and work for this, as well as for the entire project, are under the supervision of Frank D. Chase, Inc., Chicago.

Waterworks and Hydraulics Monthly Issue

ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials

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A Socialist Preaches the Doctrine of Greater Production

The most progressive men in the Socialist party are beginning to preach the doctrine of greater labor efficiency. This is certainly an encouraging symptom, for until recently it was rare that a socialist advocated anything save community ownership of capital and a more equitable distribution of income. It was usually taken for granted that the total yearly income is adequate if equitably distributed. John Spargo, socialist, recently said:

> If the working class of this or any other country should take possession of the existing organization of production there would not be enough in the fund now going to the capitalist class to satisfy the requirements of the workers, even if not a penny of compensation were paid to the expropriated owners. Kautsky, among others, has courageously faced this fact and insisted that "it will be one of the imperative tasks of the social revolution not simply to continue but also to increase production; the victorious proletariat must extend production rapidly if it is able to satisfy the enormous demands that will be made upon the new regime."

Spargo adds that "every serious student of the problem has realized that the first great task of any socialist society must be to increase the productivity of labor." True, but in view of the rarity of such utterances as this by socialist writers, is it not inferable that very few of them have hitherto been "serious students of the problem"? For generations the disciples of Karl Marx have been preaching on quite a different text. They have argued without ceasing that if capitalists would cease robbing the workers, the workers could live in affluence. Possibly the grand object lesson given by a socialized Russia has served to awaken a dawning recognition of the fact that quite as important as equitable distribution of income among workers is the production of liberal income by them. First, enough game must be killed by the hunters before all can be adequately fed.

A professor of economics at the University of Wisconsin recently gathered and published statistics to show that only 25 per cent of all the annual income in America goes to capital as interest and dividends. If every worker were to receive a 25 per cent increment in his wage, all that now goes as a reward to capital would go to the workers. But how many of them would then be satisfied? Would another dollar a day to the average employe end all grumbling? If it would, we doubt not that the average capitalist could be persuaded to give up every bit of his present interest and dividends, provided the employes would agree thereafter to do their very best. For if this were done, the total annual production could be speedily increased fully 50 per cent, thus making the future interest and dividends as great as they are now.

One of the troubles is that the average employe is prone to shirk.

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

Defective education and failure to acquire industrous habits are two of the three main causes of the "soldiering" that is so prevalent. The third main cause is the selfishness of capitalists and proprietors.

The other day Andrew Carnegie passed to the Great Beyond, and his passing was the occasion of a grand editorial chorus of praise. He was a great man. His benefactions were enormous. He had been largely instrumental in lowering the cost of steel. The general acclaim that his death occasioned was deserved. Yet, had his early life been one to inculcate less acquisitive, and more unselfish habits, he might have had a far greater and more sorrowful throng of mourners. Instead of piling up his three hundred millions of dollars, suppose he had built homes for his employes and had paid them larger wages. Would such acts not have yielded him much greater satisfaction in life and a grander tribute in death? The hundreds of libraries that he gave away are regarded by many of his former employes as being so many hundreds of monuments erected to Andrew Carnegie at their expense.

Yet he acted generously and in a way to command the admiration of nearly all the world—all save a large number of his former employes. He acted as he did because he was born and raised in an atmosphere of fierce competition, an era that bred selfishness. That he escaped the contaminating influence to the extent that he did is greatly to his credit. Still it is lamentable that he could not free himself entirely from his habits, and reward more generously the very workmen who had helped him to attain such wealth. As a Scotchman he was clannish. Why could he not have made his employes his clan? Is it too much to hope that we are entering an era of industrial clanship, when the great industrial leaders will provide for their own industrial "families" before seeking to extend their benefactions more widely? There are many signs that indicate the imminence of such a change.

The Importance of a Correct Definition of Engineering

Henry Gordon Stott, a past president of the American Institute of Electrical Engineers, is credited with the definition of engineering that is written on the wall of the engineers' library in New York: "Engineering, the art of organizing and directing men, and controlling the forces and material of Nature for the benefit of the human race." The influence of Tredgold's old definition is plainly to be seen in Mr. Stott's definition, for Tredgold defined engineering as "the art of directing the great sources of power in nature for the benefit of the human race." Mr. Stott has added "the directing of men." The superfluous words "for the benefit of the human race" still remain.

Mr. Stott's definition has one fault of Tredgold's definition, namely, failure to specify so precisely as to exclude others than engineers. A farmer, for example, falls within this definition.

Mr. S. E. Lindsay, engineer for the Puget Sound Traction, Light and Power Co., Seattle, has recently proposed the following:

"Engineering is the practice of safe and economic application of the scientific laws governing the forces and materials of nature by means of organization, design and construction, for the general benefit of mankind.

"An Engineer is one who is properly qualified to engage in the practice of engineering."

"The writer suggests that the various national and local engineering societies use all reasonable means to have legal recognition given some suitable definition of Engineering and Engineer. The above are offered for discussion and improvement."

If the clause "for the general benefit of mankind" is eliminated, Mr. Lindsay's definition is quite similar to the one first given in Gillette's Handbook of Cost Data ten years ago, namely, "Engineering is the conscious application of science to the problems of economic production." Mr. Gillette pointed out that since management had become a science it was unnecessary specifically to mention the management of men in defining engineering. In the new Handbook of Mechanical and Electrical Engineering by Gillette and Dana, Mr. Gillette's original definition is slightly changed, and it reads: "Engineering is the systematic application of science to the problems of economic production." It seems preferable to exclude merely an occasional or haphazard application of science, and to specify a systematic application. The word production is obviously used in its broad economic sense, which includes all acts necessary to render a "service" to a "consumer." Henry George very clearly pointed out, more than 30 years ago, that, in a broad, economic sense, every man who renders a useful service to his fellow man is a producer. For example, he held—and quite correctly—that a teacher is as truly a producer as is a coal miner or a farmer. If, then, we accept this broad definition of production, it is redundant to add the clause "for the benefit of mankind."

In his speech of welcome to Herbert Hoover (see our issue of Sept. 24) William L. Saunders said that the Stott definition of engineering "would have been amazing 40 years ago." We go farther and say that it amazed engineers only ten years ago, and that even now the majority of the older engineers have scarcely recovered from their astonishment.

Ten years ago Engineering and Contracting began the first systematic campaign to persuade engineers that "management engineering" was a new branch of engineering that deserved recognition as such. The proposition was so novel then that the two leading civil engineering periodicals of that day met it with editorial ridicule. It required several years of continuous editorial hammering, before Engineering and Contracting was able to use the expression "science of management" without exciting an editorial guffaw from those two periodicals, not to mention others. Gradually, however, it began to be realized that a new and broader engineering era had arrived, one that made the old definitions of engineering obsolete, and one that was eventually destined to bring about great changes in the teaching and practice of engineering.

There is much more than a word quibble in these fights over definitions of terms that relate to great classes of human activities, as those who have been most active in this particular controversy are well aware. A definition is a brief specification. A definition of engineering specifies what human activities are of an engineering nature. Most of the older engineers at first refused to revise the Tredgold definition so as to admit "management engineers," "industrial engineers," "efficiency engineers," "cost analysis engineers," and the like, to the brotherhood of technical engineers. Even yet the requirements for membership in many of the great engineering societies are so worded that, if taken literally, a management engineer could not become a full member without qualifying as a designing or constructing engineer. Thus the old, narrow conception of engineering still survives in the by-laws of engineering societies, even though a modern definition "is written in large letters on the wall of the engineers' library in New York."

Why Judge Gary Opposes the Closed Shop

More than a third of a million men are employed by the U. S. Steel Corporation at an average wage of $6.27 a day. About 56 per cent of these men work 10 hours, about 25 per cent work 8 hours, and about 19 per cent work 12 hours daily. The administration and selling forces are not included in calculating the average of $6.27. In 1914 the average wage was $2.93. Common laborers are now averaging $5 and skilled employes $6.70 a day.

These are data given by Elbert H. Gary, chairman of the board of directors of the U. S. Steel Corp., in his testimony before the U. S. Senate committee on education and labor. Judge Gary claims that no other large corporation in the world pays higher average wages than these, and the labor union leaders admit that the present strike is not primarily a strike for better wages. Judge Gary states that the labor union leaders are striking to secure the "closed shop," which he will never grant. The labor leaders deny that this is their object. However, they admit that the strike was called because Judge Gary refused to confer with them as representatives of the unions. Judge Gary said:

> It has been my policy not to deal with union labor leaders at any time, because we don't believe in contracting with unions.
>
> We are not antagonistic to unions. We recognize that the men have a perfect right to organize, but we hold that we are not obliged to contract with them.
>
> The issue is the closed shop or the open shop. If you make a contract with a union you establish a closed shop.

It is a fundamental principle which you can't arbitrate. The open shop is essential to our prosperity. The closed shop means less production, less work, and higher costs. There is nothing more important in reducing the cost of living than that a manufacturing establishment may operate unrestricted by labor unions.

When an executive of broad knowledge and keen sympathy for employes takes such a stand as this against labor unions, it will not do to charge him with "seventeenth century autocracy." Rather should the labor union leaders ask themselves whether they are not the real exponents of seventeenth century methods, the methods of the ancient trade guilds that restricted output and opposed labor-saving devices. When labor union leaders cease to advocate uneconomic policies, then, and not till then, will employers cease to be antagonistic to the "closed shop."

In America we have been relatively free from labor union restriction of output, not so much because the union leaders have advocated a big day's work for a big day's pay, but because such industrial leaders as Judge Gary have successfully fought against labor union restriction of output. In Great Britain, on the other hand, employers in many lines have long been dominated by their employes. When the world war made it necessary to speed up all work in England, there was an astonishing revelation of the previous inefficiency of the average workman. Women with no previous training took the places of skilled workmen and turned out two to four times as much work daily! Such facts as these are the underlying reasons for the strenuous opposition of so many American employers to the "closed shop."

It is urged by American labor union leaders that they are not so blind as their English cousins, and that they do not advocate restriction of output. Of some union leaders this is true, but how many of these leaders have yet come out openly with a declaration in favor of payment in proportion to performance? On the other hand, who was it that recently forced the government to abandon piece rate and bonus systems of payments in railway shops and government ship yards? Who was it that secured the passage of "full crew laws" in eight states? Who is it that is now demanding a working week of only 30 hours for the coal miners?

No, the leaders of American labor unions can not persuade the general public that the opposition to the "closed shop" is an evidence of "seventeenth century autocracy," so long as they themselves continue to advocate false economic principles whose origin is prehistoric.

In India, long before histories were written, workmen in every trade had enforced the "closed shop" principle, and they still enforce it. But they call it by another name, "caste." Every man is born into a trade or occupation, and can not get out of it. "Caste" forbids a porter to water a lawn, or drive a nail, or sweep a floor for his employer. The employer must have men of different "caste" for each different occupation. Does this savor rather strong of our own labor restrictions in the building trades, where, for example, a plumber is prohibited from assisting a carpenter? Well, it is the same old prehistoric principle at work, the principle of restricted output. It is a hereditary belief in India. In America it has yet to reach that stage, and there are several million American employers who are determined that it never shall.

Omaha Lacks Sewers and Engineering Propaganda to Secure Them

City Engineer Bruce, of Omaha, estimates that the city should build $2,700,000 worth of sewers. But under the law sewer bonds in excess of $200,000 annually can not be issued without a favorable vote by the people. This is typical of the way in which city councils are often restrained from going ahead with necessary municipal improvements.

Until engineering societies undertake to secure revision of restrictive laws and city charters there is slight likelihood that adequate expenditures for municipal improvements will be made: We suggest to the engineers of Omaha that they set an example for other engineers by conducting a campaign to change the law that now ties the hands of the city council. If the board of directors of a railway were compelled to submit to a vote of all the stockholders every proposition that involved the expenditure of more than $200,000 annually for plant extensions and improvements, it is evident that that railway would show scant improvement or growth. Equally clear should it be that a city can not progress properly if its board of directors—the city council—is not free to follow the advice of the city engineer on all matters relating to public work betterments and additions.

Recommended Salary Increases for Engineers of New York City

The Public Service Committee of the New York Chapter of the American Association of Engineers has made its report on the present salaries of engineers of the City of New York, with recommendations for increases. The committee recommends:

(1) A graded increase of salaries to be granted to all technical employes, ranging from 73 per cent for the lowest paid to 20 per cent for those receiving more than $5,000 per annum, the increase for the city amounting to a total of $930,000, for the commissions to $516,000, a grand total of $1,446,000.

(2) A flat increase of approximately $500 as an absolute minimum increase which should be granted to each employe if it is impossible to adopt recommendation (1) at the present time, the increased annual salary being adjusted into multiples of $120 for convenience in accounting, the increase for the city amounting to $612,000 and for the commissions to $356,000, a grand total of $968,000.

The $500 flat increase recommends as an alternative adjustment amounts to the following percentages for various grades:

Present Salaries.	Per cent of Increase.
$ 940 to $1,200	From 53.0 to 42.3
1,240 to 1,600	From 45.0 to 32.5
1,620 to 1,800	From 34.1 to 26.7
1,832 to 2,000	From 31.0 to 25.0
2,010 to 2,400	From 26.1 to 20.0
2,460 to 3,000	From 22.0 to 16.0
3,180 to 4,260	From 17.0 to 12.1
4,500 to 5,280	From 12.6 to 9.1
5,500 to 7,000	From 9.1 to 6.3

Salaries above $7,000 are treated as individual cases.

Adjusted salary is present salary plus $500 per year adjusted to nearest multiple of $120 per annum. The percentages shown are based on the adjusted salaries.

Hoover for President

Of the triumvirate of heroic figures that emerge from the Great War, Herbert Hoover stands forth with a distinction new to the annals of the race. Destiny accords to few men so overflowing a measure of successful and notable achievement, or such fervent appreciation of public service well performed.

New York has received perhaps two million Americans that served "over there," and the Grand Ballroom of the Waldorf has served as a setting for many important and historic episodes, but on no previous occasion has it assembled a more distinguished or representative American gathering than that which welcomed Hoover, engineer, general, master executive, and man, back to his home and to his own people.

Hoover is now at the very peak of his power—spiritual, intellectual, moral, physical. No other man embodies to such superlative degree the technical equipment, world experience, and tested and proved ability as an organizer of industrial resources. The world's best-loved man, Hoover makes at this hour an impelling appeal to all constructive elements of American citizenship. Tied to no party, owing no faction or class allegiance he would win to his support all elements of American life that are disgusted and weary of the incessant and futile playing at the 1900 brand of politics that has discredited and disgraced Congress for the last five years. Mention, at the reception in his honor, of his conspicuous availability as the country's next Chief Executive brought that notable assemblage to its feet as one man, with a roar of cheers as spontaneous as it was sincere.

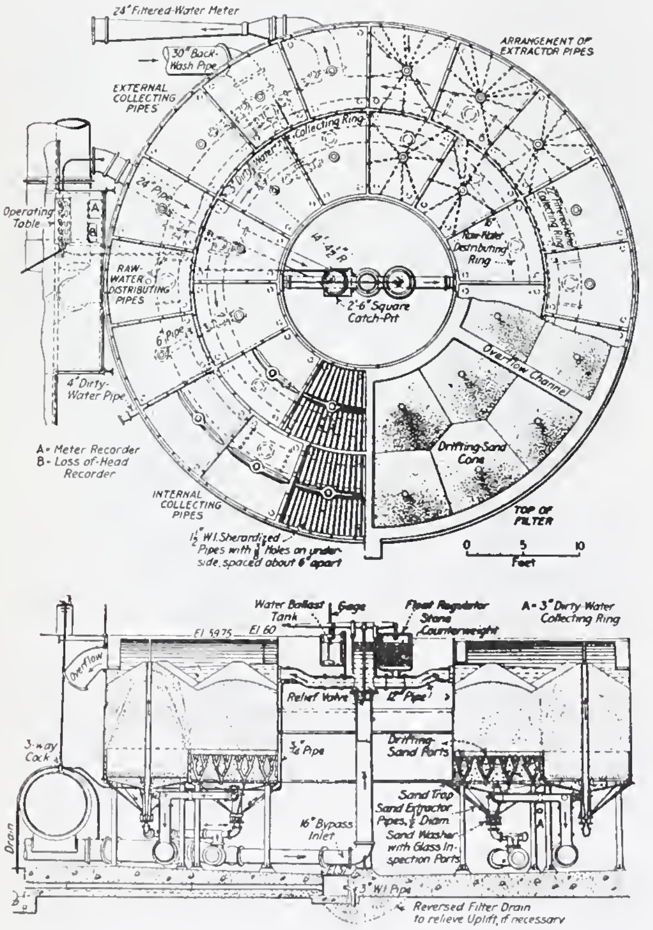
Hoover has richly earned a rest. He must have it. But he may not, with the consent of the people of America, retire.

That part of Hoover's address, delivered on the occasion of his reception on Sept. 16, dealing with the future of America, constitutes a veritable charter of the coming industrial dispensation. It is his platform. It is just.

The Journal presents for nomination for President of the United States of America at the election of 1920, Herbert Clark Hoover, Servant of Humanity.—Editorial in Engineering and Mining Journal.

Drifting Sand Filtration System of Toronto

The purification of the water supply for the city of Toronto, Ont., is effected by means of two systems, one a slow sand and the other a mechanical of the drifting sand type. The water is drawn from Lake Ontario to the south of Toronto Island, two intakes being situated a little over 2,000 ft. from the shore, submerged in about 60 and 80 ft. of water, respectively. The slow sand system has given excellent results, but when an extension was found necessary in 1914, the city decided on mechanical filtration, the reasons given being difficulties in operation, caused by a combination of occasional high turbidity and the low temperature in the winter months.


24" Filtered-Water Meter
30" Back-Wash Pipe
EXTERNAL COLLECTING PIPES
ARRANGEMENT OF EXTRACTOR PIPES
Collecting Ring
3" Dirty-Water
24" Pipe
Operating Table
A
B
RAW-WATER DISTRIBUTING PIPES
14'-4½" R
16" Raw-Water Distributing Ring
Filtered-Water Collecting Ring
2'-6" Square Catch-Pit
6" Pipe
4" Dirty-Water Pipe
Overflow Channel
Drifting-Sand Cone
A - Meter Recorder
B - Loss of-Head Recorder
INTERNAL COLLECTING PIPES
TOP OF FILTER
1½" W.I. Sherardized Pipes with ⅜" Holes on underside, spaced about 6" apart
0
5
10
Feet
Water Ballast Tank
Gage
Float Regulator
Stone Counterweight
A - 3" Dirty Water Collecting Ring
El. 59.75
El. 60
Overflow
Relief Valve
12" Pipe
¾" Pipe
Drifting Sand Ports
3-way Cock
Drain
Sand Trap
Sand Extractor Pipes, ⅛" Diam.
16" Bypass Inlet
Sand Washer with Glass Inspection Ports
3" W.I. Pipe
Reversed Filter Drain to relieve Uplift, if necessary

Details of Drifting Sand Filter at Various Horizontal and Vertical Planes.

In a paper presented last week at the convention of the New England Water Works Association, Norman J. Howard, M. Am. C. S., Bacteriologist in Charge, Filtration Plant Laboratory, describes the drifting sand system and gives the results of the operation and purification effected during 1918. An abstract of the paper follows:

Throughout the paper the word "gallons" are Imperial gallons. The capacity of the plant is 60 million gallons in 24 hours, but a maximum rate of 72 million gallons daily must be maintained for a period of 10 hours. The rate of filtration is 150 million gallons per acre per day. Before describing the plant it would be well to state the two principles involved in its operation. They are the introduction of a coagulant without sedimentation and the necessity for a drifting as well as a stationary body of sand in the filter. These would seem to be two great differences existing between modern mechanical plants of the gravity type, and the drifting sand gravity filter.

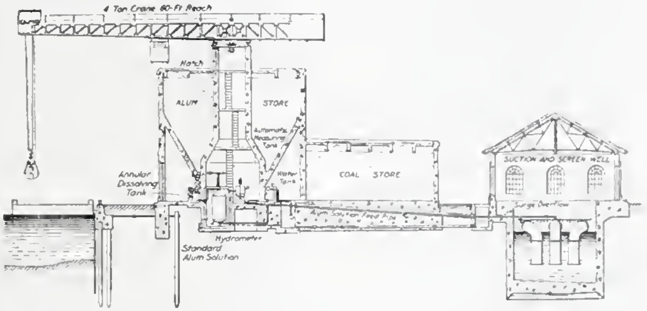
In the Toronto plant the water flows by gravity from the intake into a suction well where the coagulant is introduced, the water being pumped directly to the filters.

Coagulation Plant.—The coagulation plant consists of a large storage bin in which is stored alumina sulphate used for coagulation purposes. Through a number of control doors the chemical is automatically fed to two dissolving channels, the density of which is kept from 12° to 14° B. (about 15 per cent solution). The strong solution passes into a hydrometer chamber, where it is automatically diluted to the required strength. The hydrometer is poised in the solution between two valves, one discharging alum and the other water. Any vertical movement of the hydrometer opens one valve and closes the other. The tank is made of concrete, while the hydrometer is steel, thickly covered with paraffin wax, and has a displacement of 6,000 lb. of solution. It is weighted so as to just float in solutions of alum ranging between four per cent and 10 per cent. Owing to the differences in the density of alum and water, circulation is maintained. The heavier liquor coming in at the top immediately starts traveling downwards and meets the lighter liquid rising upwards, at the point of discharge a perfect mixture is obtained, it being impossible to detect stratification. A beam with knife edges above the hydrometer, which is extremely sensitive, provides for permanent adjustment and also for altering the density of the solution. Along the beam is a scale of divisions graduated in 1/10th grains. The solution of alum next discharges into an orifice chamber. A mechanical device regulates the discharge of solution which is proportionate to the quantity of water being pumped. From the measuring tank the alum passes through a lead pipe to the suction well and is then pumped to the filters.

Pumping Station.—The lift of water from the well to the filters is 32 ft. The pumping station includes three electrically driven pumps with a combined capacity of 100 million gallons and a lift of 32 ft. Besides these, there are a two-million gallon auxiliary pump with 32-ft. lift, two half-million gallon backwash tank pumps with 100-ft. lift, two one-million gallon drainage pumps with 20-ft. lift and two hydraulic-pressure pumps, with a capacity of 8,640 gallons a day under 700 lbs. per square inch. The discharge of the main pumps is controlled automatically by the level of the water in the filter tanks, through pilot valves, operating hydraulic valves on the discharge of the pumps. There has also been installed a steam turbo-generator set, in case the electric power should fail.

Filters.—The multiple filter unit system was adopted in Toronto and consists of ten units, each having a nominal capacity of 6,000,000 gal. Each filter is made of steel, is 14 ft. high, 50 ft. in diameter, and is divided into thirty smaller units. These units are nested together in two rings of 18 and 12, respectively. In the center of the filter is a space 16⅔ ft. in diameter, in which is placed the raw water control balance. Each of the thirty units form a separate quadrilateral unit with sand extractors, sand washer and filtered water collecting system. For backwashing, an overflow channel 15 in. wide and approximately 3 ft. deep is placed round the outer ring. At the bottom of each filter, partly embedded in the concrete, is a cast-iron collector pipe for the filtered water. Running out from the collecting pipe are a series of 1½ in. wrought iron sheradized pipes, having ⅜-in. holes drilled on the underside, spaced about 6 in. apart. These pipes have a cap on the outer end and the inner end is screwed into the cast-iron collector. On the top of the pipes is rounded gravel in three grades, varying from ¾ in. to 3/16 in. to a depth of 10 in., and above this is 9 ft. of sand. The total amount of sand in each filter is 600 cu. yd. No screens are used between the gravel and the sand. The sand has an average effective size of .375 mm., and a uniformity coefficient of from 1.6 to 2. Around each small unit is a system of slots and the drifting sand is withdrawn from the filter by means of extractor pipes, through which the sand flows to the bottom of the filter unit into a sand washer. At the sand washer the sand falls to the bottom through a current of raw water and is thus cleaned. It is picked up by the incoming raw water and carried back to the filter. The dirty water impurities or suspended matter pass upward and out at the top of the sand washer by an outlet suitably controlled. A water jet is provided to assist the flow of sand through the extractor pipes, and, below the point of discharge, a glass inspection port is provided, so that the flow of sand from each extractor pipe can be observed. The sand washers are of cast iron. The throats are relined when occasion arises with wrought-iron pipe liners, specially hardened by a carbonizing process. The liners are in three steps and are 13½ in. high.

Operation.—The coagulant is introduced as the water goes direct to the filters, on the suction side of the pump. Owing to the operation of the drifting sand system, the sand contained in the filters resolves itself into two bodies—a stationary sand body supported by the gravel resting on the water collecting system and a drifting sand body lying between the surface of the stationary sand and the sides of the filter. By causing the sand to drift across the path of the raw water, a large proportion of the impurities, including the aluminum hydrate, and the bacteria which have been caught up by the coagulant, are carried out along with a portion of the drifiting sand. The stationary sand takes out the remaining impurities. The treated raw water enters the filter partly by a standpipe running through the center of the unit, which passes through a sandwasher in the bottom, and delivers above the sand at the tope of the pipe, and partly through a by-pass. Within the sandwasher the raw water pipe is constructed similar to that of the tube of a Venturi meter and the drifting sand after being collected and washed in the sandwasher is inducted into the raw water at the throat of the Venturi tube. This sand passes up the standpipe with the raw water and is delivered at the top of the filter. The drifting sand forms a volcano-like cone that continuously drifts away and is being replaced with the washed sand from the sand washer, leaving a round top body of stationary sand below, resting upon the filtered water collecting system. The final purification is dependent on this body of stationary sand. The rate of flow of water passing through the by-pass may be varied in such a way as to suit the conditions of the raw water. In times of high turbidity the speed of the drifting sand is accelerated by decreasing the flow of raw water through the by-pass and increasing the flow through the standpipe. When in operation the stationary body of sand is found to be hard and compact with a cone-shaped-like surface, which is hard to penetrate. The drifting sand is of a buoyant and spongy nature and offers little resistance to penetration. In practice it is found that the slope of the drifting surface cone is a minimum of about 32° and the slope on the surface of the cone forming the stationary sand is about 64°.



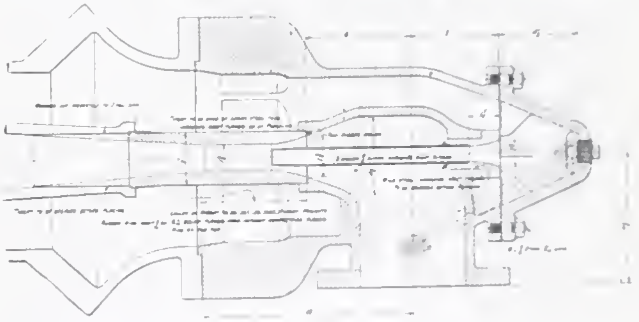
Chemical Supply Details.

Loss of Head.—The initial loss of head in the filters is 6 ft. and in the process of operation this gradually increases to 11 ft., when the filter is backwashed. Length of run of filers range between one and seven days, according to the physical condition of the raw water and the amount of alum applied. Backwashing is accomplished by reversing the flow of filtered water through the bottom of the filter. The water is obtained from an elevated tank having a capacity of 200,000 gal. and which, on account of its elevation, supplies a natural head of 25 lbs. Half the contents of the tank are passed through the filter at a gradually increasing rate, the first 100,000 gallons taking fifteen minutes, while the remaining quantity is passed through rapidly, the whole operation being completed in 20 minutes. The filter is then run to waste for 20 minutes, after which it is put into commission. The amount of dirty waste water passing through the sand washer is 2 per cent, while an additional 1 per cent to 2 per cent is used for backwashing and waste purposes.

Problems Encountered. On a big plant embracing an entirely new system, it was expected that numerous problems would be encountered, particularly when the plant was put in commission, but, with few exceptions, the difficulties have been overcome, and in no case can they be considered serious. In the early days, the biggest problem was to get a high grade sand, about two-thirds of the sand originally placed in the filters, amounting to over 4,000 cu. yd., had to be taken out and replaced at the expense of the contractor. At present the sand, while being satisfactory, is not quite uniform, having an effective size which varies between .35 and .4 mm. In the chemical house some inconvenience was caused by the corrosive action of the aluminum sulphate solution on the slotted trunk, through which the solution is discharged into the raw water. The trunk was made of vanadium silver, which has since been replaced by one made of pure copper. Tests are at present being conducted in the laboratory on a composition consisting of copper 92 parts lead 8 parts containing 1 per cent of antimony.

Sand Scour.—The question of sand scour has been the most troublesome. When the filters were first put in commission, the cast-iron throats did not wear as long as was expected, and they were relined, first with extra heavy black iron pipe and finally with similar pipe carbonized. Porcelain was tried but was unsuitable and experiments with rubber are now under way. Most of the scour observed has been traced to a tail eddy, which forms at the back of the sand nozzle by the water passing it. By using the modified sand washer base the scour has been greatly reduced, and a number of new washers are being installed. Some trouble was caused in one filter by too rapid backwashing, which resulted in the disturbance of the gravel. The filter was emptied and the gravel replaced by 4 in. of 1 in. gravel, and 6 in. of cemented gravel, in the proportion of 15 of gravel to 1 of cement. The gravel used was the material which passed through a screen, three meshes to the inch and was retained on a screen having five meshes to the inch. This has proved to be very satisfactory.

Operating Results.—It has been previously mentioned that the raw water is subject to rapid changes. Frequently the water becomes heavily polluted after less than 8 hours' change in the meteorological conditions. This makes the treatment exceedingly difficult, as occasionally a sudden pollution has occurred and an insufficient quantity of alum applied, with the result that the efficiency of the plant has been impaired. Regarding the expression of results, inclusive and exclusive, it was felt that an explanation should be offered for same. The results excluded are, one in September and two in October, the reasons being that on two occasions ab-



Improved Sand Washer.

RESULTS FROM DRIFTING SAND PLANT IN 1918.

Month.	Av. amount of water filtered, million imperial gallons.	Av. amount of aluminum sulphate applied in grains per gallon.	Raw water Max.	Raw water Min	Raw water Av.	Turbidity. Max.	Filtered water. Min.	Av.
January	30.95	0.98	80	1	6.2	under 1	under 1	under 1
February	33.16	0.65	24	1	3.9	under 1	under 1	under 1
March	33.63	0.92	54	1	12.7	3	under 1	under 1
April	32.49	1.48	160	1	27.9	18	1	2.4
May	32.74	1.04	7	1	2.1	under 1	under 1	under i
June	31.76	0.82	2	1	1.3	under 1	under 1	under 1
July	39.13	0.61	3	1	1.5	1	under 1	under 1
August	38.00	1.08	10	1	1.8	1	under 1	under 1
September	36.9	1.02	25	1	2.8	under 1	und r 1	under 1
October	40.61	1.2	4	1	1.4	under 1	under 1	under 1
November	44.19	1.07	35	1	2.9	under 1	under 1	under 1
December	37.7	1.3	75	1	21.3	under 1	under 1	under 1
Yearly average	36.0	1.027	..	..	....		under 1	

The average amount of chlorine applied to the water was .2 parts per million.

normal pollutions occurred when the bacterial count in the raw water was in the neighborhood of 15,000 per c.c., and at the same time an insufficient quantity of coagulant (1.5 grains per gallon) was being applied. On the other occasion the alum was reduced too soon following a change in the direction of the wind. When chemical tests were made it was found that the water was still polluted, and consequently the alum was again increased. During the intervening period the sample was collected and proved to be unsatisfactory. The inclusion of these three results materially alters the average number of bacteria present, and also lowers the Colon efficiency. The average number of bacteria per c.c. growing on standard agar, 37-39° C., was 369.5 in the raw and 53.4 in the filtered, inclusive of all results showing an average reduction of 85.4 per cent. Excluding three records for reasons previously specified, the figure was 303.6 in the raw and 34.7 in the filtered, with an average reduction of 88.4 per cent. The indicated number of B. Coli per 100 and 1 c.c. was 612 and 6.12 in the raw and 31.70 and .317 respectively in the filtered, with a total average reduction of 94.8 per cent. If the three records before mentioned are excluded, the raw water would show 608 per 100 c.c. and 6.08 per 1 c.c., while the filtered water figure would be 22.0 per 100 c.c. and 0.22 per 1 c.c., with an average percentage reduction of 96.4. The chlorinated water showed an average bacterial count of 1.72 per c.c., while only two samples out of 1,900 samples examined showed the presence of B. Coli in 1 c.c. This gives a total removal of 99.9 per cent.

Sand Cones of Drifting Sand Filter.

Turbidity.—Particular attention has always been given to the clarification of the water, and it would be well to point out that the turbidity figures given are only those actually occurring at 9 a. m. daily. During the month of April the figure in the raw water ran up as high as 550 parts per million, and the maximum figure recorded in the table as occurring in the filtered water followed this high period of turbidity. The raw water figure given in the table as 160, was the degree of turbidity actually present in the raw water half an hour previous to the collection of the filtered water sample, this being the estimated time for the water to pass through the filter from the time the coagulant was first added. It would seem to be scientifically incorrect to give only one set of figures, as a wrong impression might easily be formed.

Conclusions.—The original specifications called for certain efficiencies being obtained on an average amount of one grain per Imperial gallon of aluminum sulphate, this figure being largely based upon the results obtained on the experimental plant, on the Humber Bay water in Toronto. As a result of practical experience on the mechanical filtration of Lake Ontario water, considerable modification has had to be made as regards the operation of the new plant. Conclusive evidence has been forthcoming from experiments and borne out by actual results, that Lake Ontario water cannot be bacteriologically purified to a high degree by mechanical filtration, when only an average dose of aluminum sulphate of one grain per Imperial gallon is applied. The actual purification effected by the drifting sand filters, in 1918, was on an average application of 1,027 grains per Imperial gallon, and the results obtained on such a small amount are satisfactory. It has been clearly demonstrated that if a higher dose of alum was applied, a corresponding degree of purification was obtained. The economical question, however, had to be taken into consideration on account of the enormous cost of aluminum sulphate, and when it is considered that during periods of high pollution as much as 2.5 grains per gallon was applied, a definite economical as well as a practical policy of operation had to be adopted.

The summary of conclusions formed are as follows:

1. That Lake Ontario water can be treated effectively by mechanical filtration.

2. During the year the composition of the water appears to undergo two distinct changes, which make the treatment of the water difficult.

3. That in the summer months more coagulant is necessary than in the winter period.

4. That the purification effected by the drifting sand filters during 1918, upon an average dose of 1 grain per gallon of alum, was satisfactory.

Progress in Water Turbine Design

Progress in the design of water turbines has not been so marked in the last four years as in the preceding four years. However, research work has been carried on to a certain extent, the benefit of which will be recognized in the near future. Such is the opinion expressed by the Committee on Prime Movers of the Canadian Electrical Association and contained in their annual report.

Efficiencies of 92 to 93 per cent for runners have already been obtained in several plants, which is probably near the maximum obtainable, but in order to maintain this efficiency hydraulic turbine engineers are now carefully looking into the design of all passageways with particular reference to the draft tubes. The tendency is toward deeper draft tubes and a reduction of velocities when making the turn from the vertical to the horizontal. It is also realized that an improvement in the design of intakes can be made, especially for low head plants.

A difference of opinion still exists as to the number of units to install, but this generally resolves itself into a study of the transmission and the importance of continuous operation.

The single runner vertical shaft units have proven such a success that practically all new plants of a similar nature are now being equipped with this type of units. While a few years ago a specific record of 100 was considered high, manufacturers now claim to be able to build low head units with a specific speed of 170.

A great deal of progress in the design of thrust bearings has been made in recent years in order to meet the increase in size of large vertical water wheels. The General Electric Co. has developed a spring-supported thrust bearing that automatically adjusts itself to unequal loading due to inaccuracies in workmanship or in alignment. Two of these bearings have recently been installed in the Cedar Rapids plant of the Montreal Light, Heat & Power, Consolidated, in connection with the last two 10,800-hp. units and have given entire satisfaction. They are designed to sustain a load of 550,000 lb. during continuous operation of the generating units at a normal speed of 55.6 r. p. m. These bearings suffer no injury due to interruption of water service for one-half hour under normal conditions or for a space of 20 minutes not exceeding 50 per cent above normal speed. The Kingsbury thrust bearing has been adopted by the Hydro-Electric Power Commission of Ontario on the Chippewa-Queenston development. They are designed to carry a load of 900,000 lb. at 187.5 r. p. m.

Governors have undergone no radical changes. Troubles in governor systems, however, such as corrosion of pipe lines and governor parts, where water is used as the operating fluid, are met by the introduction of soluble oil barium hydrate and potassium bichromate into the operating fluid.

A noticeable improvement in regard to accessibility, thorough lubrication and easy cleaning of turbine parts has taken place.

Methods of Effecting Economies in Water Works Operation*

By HOMER V. KNOUSE,
Assistant Superintendent and Purchasing Agent, Metropolitan Water District, Omaha, Neb.

At the outset there is one thing that is emphasized by the writer, namely, that none of the plans carried out have been wholly new in the instance cited, but it is believed that in most cases they are adaptations of the plans of others, or have been suggested at times by very dissimilar proposals, and possibly may be even the carrying out in its entirety of the work of some other man.

The logical step from individual efficiency is to mechanical excellence, and the factor which will control both are the records of the operation. This is a matter that every superintendent realizes, but in many cases is compelled to defer until a time when he has a few minutes free to get out the necessary forms and issue the requisite instructions to place in effect the ideas that have formulated in his mind. Too often the many demands upon the time of the superintendent do not allow him to get further than this, and it is a regrettable fact that this feature of the work is many times not in the form which would allow him quickly to locate the leaks that mean so much in economical operation. Just one instance to illustrate wherein a most decided economy has been effected at an expense that is insignificant compared with the results achieved.

Locating Leaks in Pumping Station Operation.—The main pumping station of the water district has been so arranged that every element entering into the operation of the plant is measured. Coal in and cinders out are weighed. Water pumped and water to each boiler and to each engine is passed through a steam meter. The water delivered to the settling basins and to the distribution system is passed through Venturi meters.

On the basis of this information there comes to the desk of the superintendent each morning a report showing in its final analysis a statement as to the number of foot pounds of energy developed per pound of steam in each engine, the number of pounds of water evaporated per pound of fuel in each boiler, the number of gallons of raw water pumped as well as the number of gallons of treated water put into the distribution system. Each engine and each boiler is watched, and the individual performance known each day that adjustments may be promptly made, and it is finally developed as to what the overall station duty is, and the number of pounds of water evaporated per pound of fuel burned.

Coal is the large factor in the operating cost and, therefore, this is the item in which the most interest develops. Knowing the kinds of coal that was under the boilers, and of course its cost, it is a simple matter to determine the cost per pound of water evaporated, and it is at this point that the large factor of economy may develop. Probably every operator has had a salesman from one or the other coal dealers approach him with an argument as to why he should buy that salesman's coal in preference to all others, because it contained so many thousand B. T. U.'s, and the worst part of it is that the salesman has all the best of it, for one cannot dispute a fact that is usually attested by such authorities as we all know to be above reproach. We have a feeling that there are lots of things that we could tell him about our plant, and that there are some things that he does not know about burning coal under our boilers, but in view of the array of figures that he gives we are very loath to enter into an argument when we cannot quote data on the same basis of reliability as those that he quotes. The answer is simple, in the case under consideration, and the writer has found great satisfaction in being able to reach over the desk and pick up a report showing the performance of a certain coal and ask the salesman if he can guarantee his product to perform on an equivalent basis.

A concrete example will probably explain the method more clearly than would any further discussion in the abstract. The station duty for a certain date showed that when burning coal from a specified district an evaporation of 6.0 lbs. of water per pound of fuel from and at 212 degrees was obtained in all the boilers, and from a knowledge of previous days' reports it was known that this was a fair average for this coal. The coal cost on cars at the plant was $3.50 per ton. The coal offered was quoted at $4.85 and it was a very simple problem in proportion to determine that in order to be as cheap as the coal being burned, the coal offered would have to develop an evaporation of 8.3 lb. of water per pound of coal. Previous experience with coal from this district had told us that such evaporation was very improbable, and consequently we were not deceived by any claims that were not available under our particular operating conditions. A similar process of reasoning shows the price that may be paid for any other coal, for past tests are on record showing what may be reasonably expected from many different fields. It is difficult to estimate what the net saving has been to the water district from this method, but the writer is confident that it is very large.

Use of Alum Cake as Coagulant.—Probably the next largest item that enters into the operation of this particular plant is the matter of coagulant for the settling of water, and those who are familiar with the natural state of the waters of the Missouri, perhaps better known as the "Big Muddy," can realize that it has been no inconsiderable item. Prior to the year 1916 commercial sulphate of alumina was used as a coagulant, but in that year a plant was placed in operation to manufacture a material which served the purpose in as efficient a manner and had the advantage of considerable economy. This is an alum cake plant, as developed by Mr Charles Hoover at Columbus, Ohio, and the operation over a period of three years has demonstrated its economy in a manner that is almost too good to be true. The raw materials are bauxite, obtained in Arkansas, and sulphuric acid The manufacturing process is very simple, and even the machinery in use could well be replaced in many instances by a few simple tools, and a cheap installation that would reduce the investment to a negligible figure. A product is obtained that is fully as efficient as a coagulant as the commercial product, is no more expensive to handle, and the cost of 0.60 per hundred represents a substantial saving over what would have been the cost had a contract offered in 1916 been accepted. In fact, figured on this basis, the net saving for 1918 was $15,000 on a plant equipment cost of $6,500.

Special Rigs and Methods for Handling Work.—A folding ditch barricade, so arranged that for transportation from yard to job a minimum of space would be required, with provision for suspending a red lantern in a secure manner, and being so painted that it was conspicuous under an automobile headlight, was a cheap device that has proven of considerable value. With the lantern supported from the top of the frame and the bail removed, it has been noted that the lanterns were not nearly so popular with the early morning milkman as were those whereon the bail was left in place.

A tee placed in the exhaust line from the motor of a 2-ton truck, to which was connected a flexible metal hose, proved to be a most useful piece of equipment, for it often saved the expense of sending a steamer for the thawing of a hydrant Another modification applied to the truck was the attachment of a coupling device to the body, and the fitting of suitable attachments to the tongues of all tool wagons, concrete mixers, trailers for the transporting of large pipe, trench pumps and other wheeled tools. Much time was saved, and an added security obtained that is difficult to measure in dollars, but which the operating official will recognize as being a real advancement.

Another tool, if it may be given such a name, that is present in some plants, and also absent from a considerable number, is a map of the distribution system that has been compiled with the idea of usefulness to the foreman on construction and repairs. The "Big Boss" usually has a big map of the system in his office, and the chief engineer has a lot of tracings that tell him just the things that he wants to know but too often the man on the job is left with an out-of-date blue print with innumerable scratches thereon in pencil, or in many cases he is compelled to rely on a memory already overtaxed with things that the super has told him to do as soon as he has the time. To help out this worthy individual a skeleton map was drawn on a scale of 600 ft. to the inch, and cut up into sections covering a district one mile by two miles. These maps, printed on cloth, were bound in a roll or cover having a snap clasp and which, when not in use, occupied a space of about 3 in. by 3 in. by 11 in. Shown thereon are mains, valves and hydrants only, with a numeral alongside the main to indicate its size. Its usefulness has been well proven, for even the memory of the oldest foreman will at times prove to be faulty, and especially so under the stress of a shut-out around a break where the flowing water is causing considerable damage.

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*From a paper presented at the last annual convention of the Southwestern Waterworks Association.

Metalium as Jointing for Pipe Lines.—It was probably conservatism that made the management of the water district hesitate to try a substitute for lead as a jointing material in the laying of bell and spigot water pipe. However, upon close analysis it appeared that lead was not an entirely satisfactory material for this purpose, and an investigation was made with a view to determine its failings, and to investigate the claims of those who offered substitutes that their assertions as to superiority over lead might be substantiated. It was in 1914 that the Metropolitan Water District began this investigation, primarily with a view to decrease the cost of construction of a large force main, but also with the idea of eliminating some of the difficulties that were inherent with lead, and to which years of use had made them somewhat callous. Chief among the difficulties was the increasing difficulty of paying the increasing scale of wages demanded by expert caulkers, and even of obtaining the services of competent men for this class of work at any price; the time necessary for the caulking of the joint before the ditch could be refilled or the pipe placed in service, and the necessity for testing the line before the refilling of the ditch due to the inability of the caulking material to take up any initial leakage. All of these factors proved to be items of considerable expense due to delays to the pipe gangs.

It was during the first day that the greatest number of objections to the new material presented themselves, for after the foreman and the workmen had become familiar with the slightly different methods of handling necessary with the improved joint a decided speeding up of the work was apparent, and when it was considered that even with the pre-war prices of lead effective that there was a saving on material alone of about $1.10 per joint, the troubles of the first day were forgotten. The workmen's attitude changed from one of skepticism to one of enthusiasm, until at the present time there would be decided objections to going back to lead.

The year following all lines, of every size, were laid with this material, and the practice has continued to the present. Many joints have been uncovered to see what their condition was after several years of installation and it has been with a great deal of pleasure that the management has noted that there has not been the slightest change during the period of use. Lines under pressure have been lowered as much as 3 ft. with only a slight leakage immediately after deflection, and which has in every case taken up as rapidly as would any slight leakage that might occur when pressure was applied after the initial installation. There has been greatly decreased trouble in joints under railroad tracks, where the tendency has been for lead to "walk out" of the joint, and it is now general practice in this department to peel the lead at the first sign of trouble and replace with metalium.

A number of instances might be cited where metalium has been useful for special jobs where no other product would be suitable, but when once its use is begun these adaptations will be apparent to the superintendent and foreman. With more than 50 miles of main laid with this material, and the joint troubles practically nil, it is felt that the management was more than justified in giving the city the benefit of greatly reduced costs with an increased efficiency.

Beeswax as a Preventive of Pump Corrosion.—The rapidly destructive corrosive effect of acid water in mines is frequently quite astonishing. Pumps have sometimes been rendered absolutely useless in two or three days. In a recent issue of Coal Age, Harry Goodman tells how a simple, cheap and efficient method of protecting mine pumps from the corrosive action of some particularly bad mine water was recently tried out successfully at Herrin, Ill. After five pumps had been put on the scrap pile one after the other, Elmer Mayor, the top boss, conceived the idea of using beeswax on the parts of the pump exposed to the action of the water. Accordingly, he took apart a new pump, carefully wiped off all grease and dirt from the faces and even from the bolts that clamped the parts together. After carefully heating the clean surfaces he applied the melted beeswax to form an even coating and bolted all the parts together with similar treated bolts. The pump was then installed and has run without any further attention except the regular oiling. Before the beeswax was tried the pumps lasted from one to three days. The treated pump has been running for several months.

Schoharie Development of Catskill Water Supply System for New York City*

By J. WALDO SMITH,
Chief Engineer, Board of Water Supply, City of New York.

Construction work for the Schoharie development is now under contract. This source is a part of the original project to secure a supply of not less than 500 million gallons of water a day from the Catskill Mountain sources, as planned by the Board of Water Supply and approved by the Board of Estimate and Apportionment of the city of New York in 1905. The original plan has been amended in detail, or perhaps it may rather be said that the plan as now being constructed has developed somewhat differently than originally outlined. The total supply for the Catskill aqueduct will be obtained from the Esopus and Schoharie sources—not less than 250 million gallons a day from each—at a less cost than was originally estimated for securing the same amount of water from the three sources of Esopus, Rondout and Schoharie Creeks.

The Esopus watershed development, which will furnish not less than 250 million gallons per day by the construction of the Ashokan reservoir, has been completed. The Catskill aqueduct, having a capacity of not less than 500 million gallons a day, and the necessary appurtenant works, have also been completed. These, together constitute the first stage of construction and have been in continuous operation since Jan. 27, 1917, the first Catskill water having been delivered to the city on Dec. 27, 1915. These works were turned over to the operating department on Aug. 1, 1917.

The Schoharie watershed is adjacent and contiguous on the north to the Esopus watershed, the divide being the main ridge of the Shandaken Mountains. Drainage from the Esopus watershed is naturally through Esopus Creek eastward into the Hudson River. Drainage from the Schoharie watershed, on the other hand, is northward into the Mohawk River. The general elevation of the upper reaches of Schoharie Creek is slightly higher than the Esopus Creek, so that an impounding reservoir and a long tunnel through the divide are the works that will be necessary to join the Schoharie watershed to the Catskill system. Thus the Catskill system will be extended northerly 36 miles from the Ashokan dam, making the total over-all distance of the Catskill system, from the Gilboa dam to the terminal reservoir in Staten Island, 156 miles.

The waters of Schoharie Creek will be impounded in a reservoir of 20 billion gallons capacity, formed by the construction of a dam in the town of Gilboa, Schoharie County, the flow line of the reservoir being at an elevation of 1,130 feet above sea level. The water will then be diverted from this reservoir through an 18-mile tunnel under the Shandaken Mountains into the upper reaches of Esopus Creek, at the village of Allaben, Ulster County, where the elevation is about 969 ft. The Schoharie waters, having thus been discharged into the natural bed of Esopus Creek, will join the natural flow of Esopus Creek and follow the natural stream bed for a distance of 11 miles into the Ashokan reservoir, where it is available for the Catskill aqueduct. Thus, in effect, the Schoharie, with its drainage area of 314 square miles above the dam, will be added to the drainage area of the Esopus Creek, which is 257 square miles above the Ashokan dam, forming together practically one drainage area of 571 square miles.

The Schoharie reservoir, of 20 billion gallons storage capacity, is very small for the extent of its contributing area and would be insufficient had not the Ashokan reservoir been constructed of the largest practicable size, 128 billion gallons, which porvided for more storage of Schoharie water in the Ashokan than will be provided in the Schoharie reservoir itself. It is therefore seen that the Schoharie reservoir is in effect, a large diverting reservoir, and it will be so operated.

The Schoharie tunnel will be constructed so as to have a carrying capacity of approximately 600 million gallons of water a day. With this arrangement our studies indicate that during the highest floods of nearly every year there will be a waste of a few days' duration, both from the Schoharie reservoir and the Ashokan reservoir.

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*Abstract of a paper presented last week at the 38th Annual Meeting of the New England Waterworks Association.

The complete Catskill system, with the Schoharie and Ashokan impounding reservoirs, together with the Kensico emergency reservoir near the city, will have the following features.

Reservoir.	Drainage area, sq. miles.	Reservoir area, sq. miles.	Available storage, mil. gallons.	Probable mean stream flow, mil. gal. day.
Ashokan storage..............	257	12.78	128,000	361
Schoharie storage............	314	1.83	20,000	406
Catskill Mountain sources..	571	14.61	148,000	767
Kensico emergency	22	3.47	29,000	18
Total Catskill system......	593	18.08	177,000	785

A sanitary survey of the watersheds shows a permanent population on the Esopus of 5,339, with an additional summer population of 5,674, giving a density of population for Esopus of 21 permanent population and a total of 43 per square mile for the total summer population. On the Schoharie the permanent population is 8,792, with an additional summer population of about 6,000, giving a density of population of 28 per square mile of permanent population and 48 per square mile of total summer population. These densities compare very favorably with published information on other watersheds. There is no probability of an appreciable increase of population, as the census figures indicate that there has been no increase in these townships for several decades, and in many cases there has been a decrease.

The estimated cost of the Schoharie development with the dam at Gilboa is $22,175,400.

It is interesting to note—and this was a very forceful argument in proceeding with the construction work on the Schoharie at this time of excessive prices—that similarly, as the introduction of Esopus water to the city in 1917 saved the city $1,300,000 a year for pumping water from sources, so also will the introduction of Schoharie water, about the end of 1924, again save the city that amount, or more, because at that time, undoubtedly, pumps will be in full operation again, the pump supply now being used as a reserve to take up the increased demand from year to year, and as a reserve in case of emergency. This amount saved for pumping will more than meet the interest and sinking fund charges for the Schoharie project, and the city will get the permanent works, delivering 250 million gallons of water a day, against the 150 million gallons pumped, and it will also have the pump supply system in reserve.

The Gilboa Dam.—Contract 203, for the Gilboa dam and appurtenances, was awarded on June 23, 1919, to the Hugh Nawn Contracting Company, Roxbury, Mass., the amount, based upon contract quantities and unit prices, being $6,819,910. The dam will be located in the town of Gilboa, Schoharie County, about 4 miles northeast of the Grand Gorge station of the Ulster & Delaware R. R. This is 66 miles by rail from Kingston, and 155 from New York. The dam will be located on the present site of the village of Gilboa, which has a population of about 300 and is the only village to be obliterated.

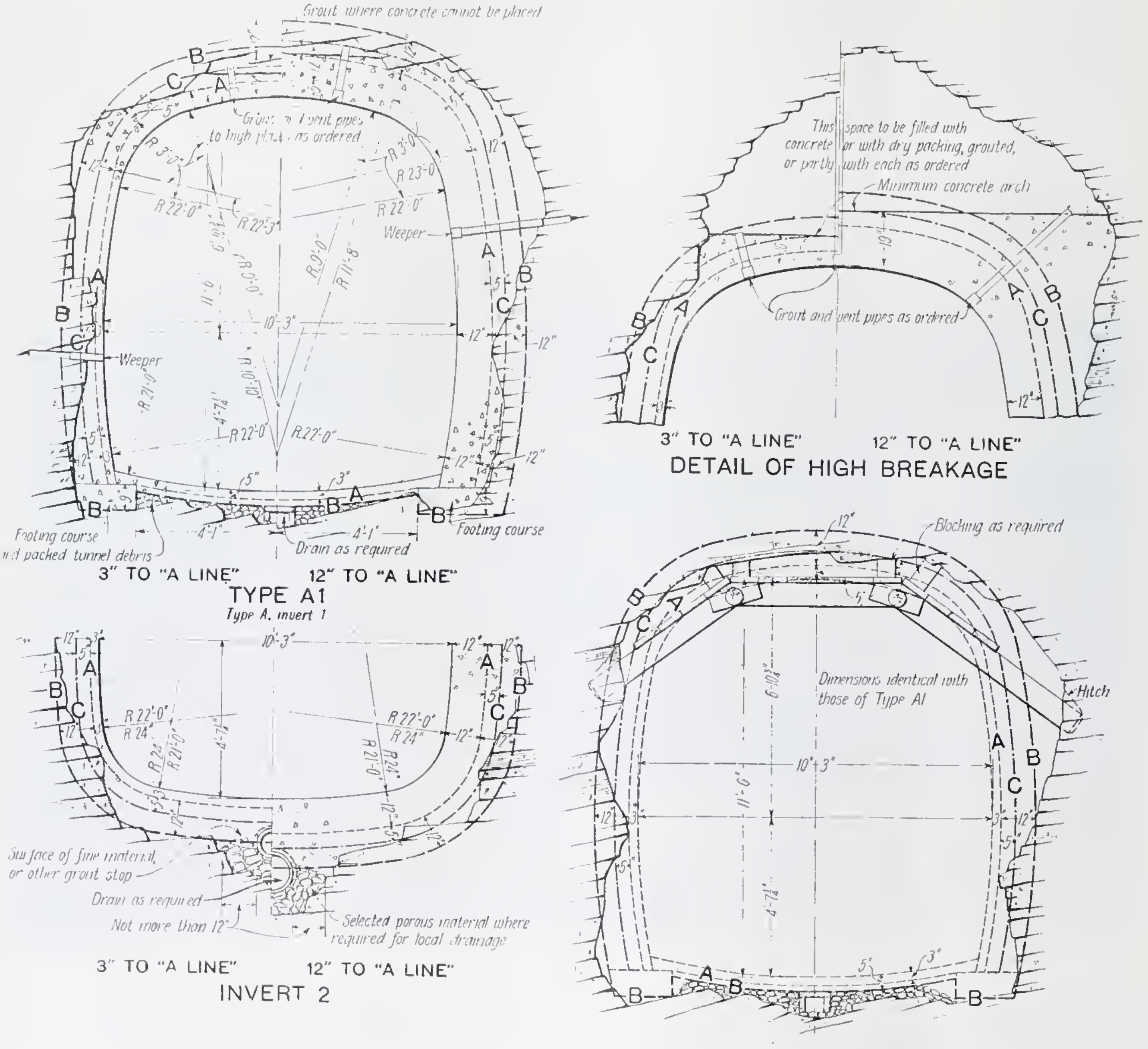
Site of Gilboa Dam. The Church is About on the Center Line of the Dam, the Crest Being About 5 Ft. Above the Top of the Church Spire.

The dam will be of two distinct types. On the east side of Schoharie Creek and in the bottom of the stream the rock is at or near the surface. On this rock foundation will be constructed an overfall masonry portion, 1,300 ft. long and 160 ft. high. The west bank is composed of a very stiff, impervious clay which extends in every direction, and the pre-glacial gorge of the stream is completely filled and deeply covered with tight and impervious material. For this side of the stream an earth embankment portion, 1,000 ft. long and approximately the same height as the masonry portion, will be built. At the transition section the dam will be flanked both upstream and downstream by a heavy masonry retaining wall to intercept the long slopes of the earth section.

The overfall section is designed with steps on the downstream side, for the purpose of breaking up and safely conducting the overflowing water down the face of the dam to the spillway channel below. There will be a cut-off wall about 20 ft. deep and 20 ft. wide under the foundation. Dovetailed contraction joints with a continuous vertical copper-strip water-stop extend across the dam from the foundation up at intervals of about 80 ft. All the masonry will be concrete, into which stones may be embedded in the sizes and proportions found practicable. All exposed surfaces are to be of selected native sandstone with mortar joints. The earth portion of the dam is of conventional design with masonry corewall and with heavy rock paving on the upstream slope.

The spillway channel, along the top of the dam, which will discharge waste waters into Schoharie Creek below, is about 80 ft. wide at the upper end and 300 ft. at the lower. The rock bottom slopes rather steeply and will be protected where necessary with masonry and substantial paving. The side of the channel away from the dam will be defined by a masonry retaining wall. A field model of the over-fall section and channel is now being constructed by the engineers to determine certain details necessary to control the overflow.

The contract also includes the construction of about three miles of highways which must be completed before active operations on the dam can begin.


Grout where concrete cannot be placed
Grout and vent pipes to high places as ordered
R 3'-0"
R 23'-0"
R 22'-0"
R 22'-3"
Weeper
R 9'-0"
R 11'-8"
11'-6"
6'-10¾"
R 10'-0"
10'-3"
4'-7¼"
R 21'-0"
12"
5"
3"
A
B
C
Footing course and packed tunnel debris
4'-1"
Drain as required
Footing course
3" TO "A LINE"
12" TO "A LINE"
This space to be filled with concrete or with dry packing, grouted, or partly with each as ordered
Minimum concrete arch
10"
Grout and vent pipes as ordered
R 24"
Surface of fine material, or other grout stop
Not more than 12"
Selected porous material where required for local drainage
Blocking as required
Dimensions identical with those of Type A1
Hitch

TYPE A1
Type A, invert 1

DETAIL OF HIGH BREAKAGE

INVERT 2

TYPE B1

Sections of Shandaken Tunnel, Types A and B, 11 ft. 6 in. x 10 ft. 3 in. and Inverts 1 and 2.

HYDRAULIC ELEMENTS.

Depth of flow in feet.	Types A1 to F1 inclusive.				Types A2 to F2 inclusive.			
	A.	p.	R.	A√R.	A.	p.	R.	A√R.
11.5	106.1	38.1	2.79	177	105.3	37.3	2.82	177
11.1	104.6	32.6	3.21	187	103.8	31.9	3.26	187
*11.0	104.0	32.1	3.25	187	103.2	31.3	3.30	187
10.0	96.6	28.8	3.35	177	95.8	28.1	3.41	177
8.0	78.1	24.6	3.18	139	77.3	23.8	3.24	139
6.0	58.2	20.6	2.83	98.0	57.4	19.8	2.90	97.7
4.0	37.8	16.6	2.28	57.2	37.0	15.8	2.34	56.6
2.0	17.6	12.6	1.40	20.8	16.8	11.8	1.43	20.1
1.0	7.82	10.55	.741	6.73	7.19	9.60	.749	6.23
** .54	3.45	9.60	.359	2.07	3.24	8.21	.395	2.04

*Maximum. **Corner of invert 1. A = area, sq. ft. p = wetted perimeter, ft. R = hydraulic radius, ft. Slope of invert = .000834. $\sqrt{s}$ — .0289.

QANTITIES PER LINEAR FOOT.

	Type A1. 3" to "A line"	Type A1. 12" to "A line"	Type A2. 3" to "A line"	Type A2. 12" to "A line"	Type B1. 3" to "A line"	Type B1. 12" to "A line"
Excavation, cu. yd.	5.72	6.74	5.92	7.27	5.72	6.74
Concrete in footings, side walls and arch, cu. yd.	1.64	2.66	....	....	1.64	2.66
Concrete in invert, cu. yd.	.15	.15	....	....	.15	.15
Concrete, total, cu. yd.	1.79	2.81	2 02	3.37	1.79	2.81
Dry packing, cu. yd.	In high breakage only, actual quantities by field measurement.					
Grout, cu. yd.	Actual quantities, by field measurement.					
Temporary timbering, M.F.B.M.	....	....	....	....	.049	.052
Forms, linear foot of tunnel	1.00	1.00	1.00	1.00	1.00	1.00
Drainage channels, linear foot of tunnel	1.00	1.00	1.00	1.00	1.00	1.00

The stream-control scheme during construction, outlined in the contract, is similar to that used at Ashokan dam, involving the placing of, first, two large steel pipes over the foundation cut-off trench, and later, the construction of an arched opening through the dam 45 ft. wide by 50 ft. high, which will be filled with concrete when the dam is completed. This opening will have an appreciable bell mouth to increase its flood capacity. Experience at Ashokan demonstrated the desirability of thus increasing the capacity. There is also a permanent blow-off, with 30-in. valve in duplicate. The principal items of the contract are 396,000 cu. yd. of earth excavation, 92,500 cu. yd. of rock excavation, 617,000 cu. yd. of refilling and embanking, 436,000 cu. yd. of masonry, and 480,000 barrels of Portland cement. The contract time is 66 months.

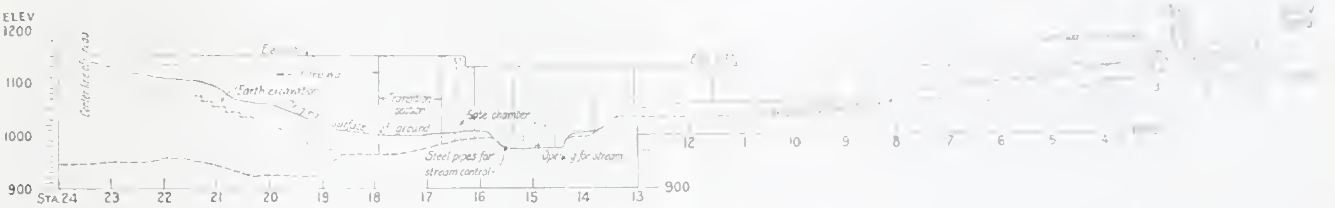
The Shandaken Tunnel.—Contract 200, for the Shandaken tunnel, was awarded November 9, 1917, to the Degnon Contracting Company of New York City, for $12,138,738, based on contract quantities and unit prices. As this is an unusually long tunnel, it was considered advisable to divide the work into two parts, upon which intending bidders might submit their proposals separately; but the low bid accepted for the entire tunnel was less than the sum of the separate part bids received. The main parts of the contract comprise the intake works, the tunnel and the outlet works.

The intake works will be located about three miles north of the village of Prattsville and two miles south of the dam on the westerly side of the reservoir. They will consist of an intake channel and chamber with superstructure and intake shaft. The chamber will be built into the rock and will house eight 3-ft. by 7-ft. sluice gates set radially in the wall of the central well or extension of the intake shaft. The superstructure will have rubble walls of native bluestone, reinforced concrete floors, steel roof trusses and steel framing for the crane over the intake shaft. This building will have two wings, providing living quarters, garage, office, machine shop and storerooms. The intake shaft will be 14 ft. in diameter, except where constricted near the top by a Venturi meter.

The tunnel extending from the intake works in a general southeasterly direction for a distance of 18 miles to the outlet works, to be located on the upper reaches of the Esopus Creek just south of the village of Allaben, will be of sufficient size and gradient to transport water from Schoharie reservoir to the upper reaches of Esopus Creek at the rate of 600 million gallons a day. The velocity of the flowing water will be 8.7 ft. per second, equal to 5[illegible] miles per hour, acting as a grade tunnel. The tunnel will be operated intermittently at varying rates, depending on the conditions of stream flow and storage. The intake sill will be at elevation 1050, and the outlet channel weir will be at elevation [illegible]. The tunnel will be in rock of shale or sandstone except for about 350 ft. of tunnel in earth adjoining the outlet, and will be lined throughout with concrete. The waterway section is of horseshoe shape, 11 ft. 6 in. high by 10 ft. 3 in. wide, inside dimensions; about 5.7 cu. yd. of excavation per linear foot, and the tunnel will have a uniform grade of [illegible] ft. per mile except for the northerly 3½ miles, which will be depressed in order to pass in rock of good quality beneath the gorge of the Bear Hill. There are seven intermediate shafts which will be permanent in order to provide ready access to the tunnel. The shafts will be lined with concrete and will have a diameter of 14 ft. inside. Small superstructures of native stone will cap each shaft and guarded openings in the floor and walls of these buildings will provide for air movements in the tunnel. The aggregate depth of shafts will be 3,238 lin. ft., the maximum depth of a single shaft being 630 ft. The minimum distance between shafts is 1.3 miles, the maximum 2.7 miles.

The greatest depth of cover is where the tunnel passes under the main divide of the Shandaken mountains, where the top of the mountain is 2,200 ft. above the tunnel. Work has been going on since the award of the contract and to July 16, 1919, about 2,800 lin. ft., or 86 per cent. of the total depth of shafts has been excavated, and 2,560 lin. ft. or 79 per cent. of the aggregate depth of shafts lined with concrete, the lining being placed in stretches following the excavation. Three of the shafts have reached tunnel grade, and the others, except the intake shaft, are nearing it. The maximum weekly progress of shaft excavation in each of the seven shafts has been between 27 and 42 lin. ft., and the average progress of all shafts 12 ft. per week.

The outlet works at Allaben on Esopus Creek will be located 11 miles above the Ashokan reservoir, or 16 miles above the Ashokan dam. They will consist of about 500 ft. of aqueduct of the cut-and-cover type, an outlet chamber and about 290 ft. of open outlet channel. The cut-and-cover aqueduct will be of horseshoe shape, 11 ft. 6 in. high by 10



Upstream Elevation of Masonry of Gilboa Dam.

STATISTICS OF ASHOKAN, SCHOHARIE AND KENSICO RESERVOIRS.

	Ashokan Storage Reservoir.	Schoharie Storage Reservoir.	Kensico Emergency Reservoir.
Capacity, total	130,000,000,000 gal.	22,000,000,000 gal.	38,000,000,000 gal.
Capacity, available	128,000,000 000 gal.	20,000,000,000 gal.	29,000,000,000 gal
Water surface	12.8 sq. miles	1.83 sq. miles	3.5 sq. miles
Land acquired	23.8 sq. miles	3.72 sq. miles	7.0 sq. miles
Elevation at top of dam, above tide	610 ft.	1,130 ft.	370 ft.
Elevation of flow line, above tide	*	1,130 ft.	355 ft
Length of reservoir	12 miles	5 miles	4 miles
Length of shore line	40 miles	12 miles	30 miles
Length of dams and dikes	5½ miles	2,300 ft	3,300 ft.
Main dam:			
Total length	4,650 ft.	2,300 ft.	1,825 ft.
Length of masonry portion	1,000 ft.	1,300 ft.†	1,825 ft.
Height (maximum)	252 ft.	160 ft.	307 ft.
Thickness at base (maximum)	190 ft.	165 ft.	235 ft.
Thickness at top (minimum)	23 ft.	15 ft.	28 ft.
Width of reservoir:			
Maximum	3 miles	4/5 mile	3 miles
Average	1 mile	2/5 mile	1 mile
Depth of reservoir:			
Maximum	190 ft.	140 ft.	155 ft.
Average	50 ft.	58 ft.	52 ft
Villages submerged	7	1	1
Permanent population of submerged area at beginning of work	2,000	350	[illegible]
Cemeteries removed	[illegible]	7	None
Bodies reinterred	[illegible]	1,330	None
Railroads relocated	11 miles	None	None
Highways discontinued	64 miles	13.6 miles	[illegible]
Highways built	40 miles	12.4 miles	[illegible]
Highway bridges built	[illegible]	2	4
Earth and rock excavation	2,500,000 cu. yd.	488,500 cu. yd.	[illegible]
Embankment	[illegible] cu. yd.	617,000 cu. yd.	[illegible]
Masonry	[illegible] cu. yd.	436,000 cu. yd	[illegible]
Cement	1,200,000 bbl.	480,000 bbl.	[illegible]
Maximum number of men employed	3,000	....	[illegible]

*West basin, 590 ft.; east basin, 587 ft. †Earth, 1,000 ft.

ft. 3 in. wide. Near the lower end it becomes a reinforced concrete waterway 11 ft. 6 in. in diameter, with a fall of 16½ ft., providing a water seal for the tunnel outlet. The outlet chamber will be an open flaring structure whose invert will slope upward to the invert, elevation 969, of the open channel. The latter will have masonry sidewalls and local stone paving. Sloping gently for 290 ft. and passing under a steel girder bridge, which will carry the highway, the channel will discharge the water from the tunnel into Esopus Creek on its way to Ashokan reservoir.

The estimated contract quantities are about 600,000 cu. yd. of rock excavation, 100,000 cu. yd. of earth excavation, 200,000 cu. yd. of concrete masonry and 445,000 bbls. of Portland cement. The contract provides direct payment for medical services for the laborers and sanitary services for the camps and working locations. The shaft work has been done with individual plants at each location, but a power line is being constructed by the contractor to bring electric energy from Kingston for the tunnel work. Within 78 calendar months the work underground must be completed so that the tunnel can be operated and all work must be completed within seven years.

Highways and Miscellaneous.—Contract 202, for the grading of about 7¾ miles of highways around the Schoharie reservoir, was awarded on June 13, 1919, to the Schunnemunk Construction Co., Highland Mills, New York, for $176,700, based on the contract quantities and unit prices.

The estimated quantities are 112,500 cu. yd. of earth and rock excavation, 7,550 cu. yd. of paving, masonry, etc., 6,500 bbls. of Portland cement and 22,000 lin. ft. of wooden guardrail. The contract time is 18 months.

Other Schoharie work not yet under contract will be a permanent highway bridge over Schoharie Creek below the dam, a highway bridge and approaches over the Manorkill, a tributary of the reservoir, and the clearing of the reservoir site. To finish the main aqueduct to the city additional tubes at 14 locations of steel-pipe siphons will be required

Who Is Responsible?

For months past there has been standing idle at Muscle Shoals, Alabama, a sixty-thousand kilowatt power plant complete in every respect and representing the best practice that skilled engineers could lay down. This installation forms part of the great nitrate plant that was to turn out nitrates by the ton for our vast explosives program.

The armistice came before the plant got into production, although the construction was carried to completion, the big turbo-generator turned over and then, after a short time, the operating crew departed and watchmen were placed in charge.

This plant was designed for the production of nitrates by the cyanamid process, and it is claimed that, with slight additional expenditure, it could be converted for the production of fertilizer for which the farmer is now required to pay such exorbitant prices. This is aside from the enormous idle investment represented.

Who is responsible? Is it the War Department or is it Congress, or, perchance, just Government inertia? It has been said that the Government has not the talent to operate the plant and is unwilling to turn it over at the figure offered by the company that would have operated it had the war continued. In any event, to have this costly equipment idle is a large and needless economic waste.—Editorial in Power.

Eleven States Have Laws Licensing Engineers.—Laws providing for the licensing of engineers are on the statute books of the following states, according to the best information obtainable by the License Committee of Engineering Council: Wyoming, 1907; Louisiana, 1908 (amended 1914); California, 1909; South Dakota, 1913; Illinois, 1915; Idaho, 1915; Florida, 1917; Oregon, 1919; Colorado, 1919; Michigan, 1919; Iowa, 1919. The License Committee is working on a draft of a typical bill which, it is intended, can be used if necessity should arise in states proposing new legislation on this object, or in those proposing revisions, so that laws enacted for licensing engineers may be uniform, or nearly so, throughout the country. Engineering Council, however, has as yet taken no stand on the desirability of licensing or registering engineers. It desires to learn the opinions of engineers in various branches of the profession in all parts of the country and to secure as soon as possible all information that would be helpful to the committee.

Notes on Filtration Plant Operations at St. Louis

Interesting information on last year's operation of the filtration plant of St. Louis, Mo., is given by August G. Nolte, Superintendent of the plant, in the recently issued annual report of Edward E. Wall, Water Commissioner of that city. The notes following are taken from the report.

Filter Plant Operation.—During the year ending April 1, 1919, 37,673 million gallons of water were filtered at a cost of $3.10 per 1,000,000 gals. The 40 filters were continually in service, except for short periods of time when minor repairs were being made. The rate of filtration during the year varied from a maximum of 124.44 million gallons per acre per day to a minimum of 31.11, averaging 80.57 million gallons per acre per day. The maximum run of a filter was 225 hours, filtering 23.58 million gallons; the minimum run was 16.90 hours, filtering 1.97 million gallons, and the average run was 59.8 hours, filtering 6.46 million gallons. The 40 filters were washed a total of 5,828 times, using 498 million gallons of water, or 1.32 per cent of the water filtered. During the year 1,790 tons of aluminum sulphate have been used. Of this amount 1,749 tons were added to the settled water and 41 tons to the applied water at the influent pipe to each filter after washing. None was used at the influent flume at the north or south ends of the filter plant. The charge of aluminum sulphate to the settled water has varied from a maximum of 2.12 grains per gallon to a minimum of 0.23 grains, the average being 0.65 grains per gallon of water filtered.

A total of 83,160 lbs. of chlorine has been added to the filtered water, the maximum charge being 4 lbs. per 1,000,000 gals., the minimum 0 and the average 2,208 pounds per 1,000,000 gals. of water filtered.

Coating of Sand Grains.—In order to obtain information on the increased coating of the sand grains during the past two years a vertical section of the sand bed was collected from one of the filters after washing and divided into horizontal layers as shown in the table below. A comparison with a similar sample obtained two years ago is made. Treatment of each layer with hydrochloric acid was followed by a thorough washing with water. The per cent loss due to the acid treatment together with the average depth of the sample is shown.

Sample No.	Thickness of sample in inches.		Mean distance in inches from top		Per cent loss in weight due to acid treatment.	
	1917	1919	1917	1919	1917	1919
1	1	1	½	½	9.8	14.0
2	1	1	1½	1½	8.9	12.6
3	2	2	3	3	6.9	11.5
4	2	2	5	5	4.6	7.3
5	3	3	7½	7½	3.1	4.9
6	3	3	10½	10½	2.3	4.8
7	3	3	13½	13½	1.93	4.0
8	3	3	16½	16½	1.57	3.2
9	3	3	19½	19½	1.41	3.2
10	3	5	22½	23½	1.13	3.3
11	3½	..	24¼	....	0.86	...

Holes in Filter Sand Made by Fish.—Last May it was noted that fish, mostly carp, were making an unusual number of holes in the filters. These holes varied from 1 in. to mere depressions in depth and were as large as 1 in. by 2 in. in plan. The fish varied in size from mere minnows to 6 in. in length, the average being about 3 in. long. On account of the turbidity and of the depth of water (about 4½ ft.) over the sand surface while the filter is in operation, the manner in which these holes are made could not be studied, but it is supposed that the depressions are due to the impact of the fish striking the aluminum hydroxide matting on the surface of the sand, either while swimming downward in the direction of the current or while nibbling for food. There is no doubt that the depressions are due to fish because the holes are always found when fish are found, and vice versa. The depressions do not seem to interfere with the efficiency of the filters as the effluent from them has no turbidity. The situation might become more serious if more voracious fish such as catfish were present. These, however, have very seldom if ever been found on the filters.

Screening Filter Units.—The rate of wash during the year has been maintained at 15 gal. per square foot per minute. The practice of screening one section in each half of each filter unit once a month with a ¼-in. mesh screen has been continued throughout the year. This screen is 4 ft. 2 in. by 3 ft. 2 in., just wide enough and deep enough to cover the volume from gutter to gutter and from gravel to top of floating sand. The screen is pulled through the same section each month so that comparative results are obtained.

Raking Reduces Quantity of Mud-Balls.—In May the maximum number of mud-balls caught on the screen from any one filter was about 2,000, while the minimum number was 50. In August the maximum number was about 400 and the minimum 10. These mud-balls vary in size from about ⅛ to ¼ in. in diameter. This reduction in the number of mud-balls from May to August is attributed to the following procedure: During June and July the walls of each filter were raked with an ordinary gardener's rake with extension handle attached. Each filter was raked about eight times. The raking was done while the filter was being washed. At one wash one-half of the unit was raked, at the next wash the other half, etc. In tihs way no extra labor was required to do the work.

In February a test was made on each filter to determine the head lost through the filter while washing at a rate of 15 gal. per square foot per minute. The maximum head loss was 16.9 ft., in filters Nos. 14 and 32; the minimum 6.9 ft., in filter No. 8.

Locating Loose Strainer Plates.—A loose strainer plate in a filter can usually be located by a heaped spot in the gravel bed. Adjacent to the mound of gravel will be found a depression giving the exact location of the loose portion of the plate. In September an examination of the gravel surface was made in each filter. To do this a T was made of ¾-in. pipe, the vertical leg being about 15 ft. long, the horizontal legs about 6½ ft. total. This T, inverted, was moved inch by inch across the filter unit parallel to and between each two lateral gutters while the wash water was being applied. As long as the gravel surface was level the vertical leg of the T would stand perpendicular; any unevenness would tilt the vertical leg. This procedure also revealed the presence of large mud-balls in several of the filters; these were broken up with a rake. Loose strainer plates were found in nine filters. In each of these filters one or more end strainer plates were bare for a distance of from 1 to 3 ft. It was found that the nuts on the U-bolts were not drawn up all the way. In several cases the nut was only held by a few threads. This condition allowed the plate to raise each time the wash water was applied, and the force of the water threw the gravel aside. Repairs were made by regrouting the plates, drawing up the nuts and replacing the gravel.

During the year 1,872 tons of aluminum sulphate have been received and unloaded at a cost of $0.224 per ton.

The concrete sulphate dissolving boxes in the chemical room have again been resurfaced with cement mortar and coated with asphalt. The copper screens in the dissolving boxes are rapidly deteriorating and are not worth repairing so they are being replaced with boards drilled full of holes; these answer every purpose of the screens and are easily removed.

The surface of the bottom of the solution tanks is becomiug more and more raveled so that it will probably be advisable to resurface the bottom of all the tanks during the coming year. The sides are still intact.

The agitator shafts in solution tanks Nos. 1 and 2 have been renewed during the year. There is still one tank, No. 4, that has the original shaft in it; this, however, will have to be replaced shortly.

Many of the 3-in. gate valves around the chemical pumps and solution tanks are again leaking slightly. They were repaired about a year ago. This leakage causes no waste but makes handling the solution a little inconvenient. A blank lead flange has been inserted beyond each sewer valve from the solution tanks so as to insure no waste from that source. As it is only necessary to flush the tanks about once every two months, the removal of the blank flanges does not consume much time.

Bronze gate valves, around the aluminum sulphate solution, operated as frequently as they are, will not hold up for any length of time. Any attempt to keep them leak-proof would mean constant repairing. So as long as their leaking does not interfere with the proper application of the sulphate solution and does not cause any waste of solution it is better to tolerate a little leak rather than make constant repairs.

The vertical agitator motors in the chemical room have been taken apart and the parts bathed in gasoline. These motors are subject to much dust and so canvas hoods have been made to protect them.

Cleaning 4-in. Lead Solution Lines.—The 4-in. lead solution lines through which the aluminum sulphate solution is conveyed to the point of application have been cleaned several times. Instead of pulling a 4-in. leather disc through as was formerly done and which meant disconnecting a line about every 60 ft., a double rubber disc shoot through with water pressure is now used. This only necessitates disconnecting an entire line, about 800 ft. in length, at two places. The disc will pass around bends of 3-ft. radius and through the 4-in. open gate valves on the line. The water pressure required to shoot the disc has averaged from 20 to 50 lb. per square inch. No bulging whatever has resulted from this pressure. With this disc the work of cleaning is done much more thoroughly than by hand, in about one-third the time, and is really a protection to the pipe since it eliminates disconnecting and thereby preserving the peaned gaskets.

The 1¼-in. brass cocks on the 1¼-in. lead solution line to the influent of each filter have been reground several times during the year. When these need replacement globe valves should be substituted.

The bronze orifice castings in the orifice boxes of the automatic chemical meters and the conical plugs that regulate the area of the outlet have had to be repaired on account of the corrosive action of the sulphate on these parts. The bronze orifice casting was turned out about ¾ in. and an orifice bushing made that would screw into the casting so that hereafter the bushing, when deteriorated, may easily be replaced. The plugs were turned down and polished. Since these repairs were made the automatic control properly reguates the amount of solution to be fed in proportion to the amount of water passing through the 8-ft. meters.

Last July the three 4-in. venturi meters at the north end of the plant used for measuring the amount of aluminum sulphate applied to the settled water were taken apart and cleaned. The meters were so badly clogged with scale from the alum solution that the diameter at the head was reduced from 4 in. to 3 in. and at the throat from 1⅝ to 1⅜ in. Before cleaning the meters recorded and indicated about 30 per cent too fast. After cleaning the variation was only 1 per cent. It is now the practice to leave the meters disconnected when not in service because we have found that solution standing quietly in a meter deposits scale much more rapidly than when in motion.

The 4-in. tile pipe chlorine line laid as an experiment to convey the chlorinated water to the drawing conduit chamber had to be abandoned on May 20, 1918, on account of the excessive leakage from it. There was some leakage at the litharge joints but the greatest leakage occurred through the body of the pipe itself.

Durability of Cement Drain Tile in Alkali Soil.—After an interruption of two years, due to the pressure of war work, the field inspection and testing in connection with the drain tile in alkali soils has again been taken up by the Bureau of Standards, Department of Commerce. In Minnesota, pieces of tile which have been in the ground since the last inspection have been removed for test and the concrete found to be uninjured either by alkali or acids, but a number of both the best and poorest tile were found to be cracked. It is thought that sometime during the cold weather water had backed up and stood in the pipe, freezing and bursting it. A complete survey of all the most important reclamation projects in the West is to be made in the near future, and based on this work the committee in charge of the investigation will endeavor to make definite recommendations relative to the manufacture and use of cement tile in alkali soils. The results of the work already accomplished are embodied in the Bureau's Technologic Paper T95, "Durability of Cement Drain Tile in Alkali soil."

Cost of Chemicals at St. Louis, Mo.—The net cost of operation and maintenance of the water division of St. Louis, Mo., for the year ending April 1, 1919, was $218,108 greater than that of the previous year. This was due entirely to the advance in wages and salaries and in the prices paid for chemicals for purification, for coal, and for other materials and supplies. Some of the increases noted in the last annual report of the Water Commissioner were as follows:

	1916-17.	1917-18.	1918-19.
Salaries and wages	$805,440.00	$915,750.00	$[illegible],046,365.00
Sulphite of iron, per ton	12.167	12.103	23.213
Lime, per ton	4.226	6.373	9.015
Sulphite of alumina, per ton	19.013	23.708	31.077
Coal, per ton	1.528	2.459	2.972

A Page from Recent Waterworks Reports

Electrical Thawing of Water Services at Somerville, Mass.—During the winter of 1917-18 about 6 per cent of the meters of Somervile, Mass., and 4 per cent of the services were frozen at some time during January and February. In addition one 10-in., one 6-in. main and two 2-in. service mains were frozen out dead ends. The thawing was successfully done with electricity; the method is described as follows in the report of the Water Department for 1918: The electric thawing device used consisted of a 50 k.w. transformer, taking current from the Edison system 2,200-volt primary wires and delivering to the water pipes a current of varying amperage controlled by a water rheostat and conveyed by a heavy cable grounded to a fire hydrant on one side and clamped to the house service on the other, thus completing the electrical circuit. The apparatus was carried about the city on a heavy wagon drawn by a pair of horses and was set up at various points so that one connection with the primary wires would reach as many frozen services as possible, in some instances as many as eight being thus reached through cable lines several hundred feet in length. One hundred sixty-nine services were thawed by this method in a period of twelve working days, between Feb. 13 and 26, the lowest day's results being eight and the highest nineteen. About a dozen other services were tried but the desired results failed, probably on account of some poor metallic connection in the pipe line which obstructed the flow of the current and failed to heat the pipes, although evidently forming an arc which, in some instances, was sufficiently intense to melt the brass fittings and led to the necessity subsequently of digging down to and repairing the connections. On the whole the operation of the device was very satisfactory, being especially serviceable on such pipes as were too small or crooked to get an ordinary hot-water thawing tube through. It is worthy of record also that in the hands of the expert operator there was no difficulty in thawing cement-lined service pipes which had been thought, from results in other places, were, from the nature of their construction, beyond the range of this electrical method of thawing.

Water Rates at Harrisburg, Pa., on "Ready to Serve" Basis.—Owing to the increased cost of all materials and labor the Water Department at Harrisburg, Pa., decided in 1918 to raise the water rates and J. W. Ledoux, C. E., of Philadelphia, Pa., was authorized by the city council to make a general survey of all phases of the water plant and to make a recommendation as to an equitable charge to be made for water. From his report the following rates were finally adopted:

That water to all classes of consumers be charged at 43 ct. per 1,000 cu. ft., and in addition a "ready to serve" charge according to the size of the meter as follows:

Size of meter.	Amount annually.	Size of meter.	Amount annually.
½ in. and ⅝ in.	$ 4	3 in.	$ 90
¾ in.	5	4 in.	160
1 in.	10	6 in.	360
1¼ in.	15	8 in.	640
1½ in.	22	10 in.	1,000
2 in.	40	12 in.	1,440

This "ready to serve" charge is new in Harrisburg and takes the place of the old minimum charge. It can best be explained by the following from Mr. Ledoux's report:

Although so much has been said about "demand charge" it may be that many of the citizens cannot see why a demand charge is necessary in water works operation, and why a certain price per 1,000 cu. ft. or gallon does not satisfy every necessary requirement. The reason is that a water works must be designed so that its distributing system at least is capable of supplying reasonable service to every consumer even when the maximum number are drawing water simultaneously.

It is obvious that under those conditions, the larger the meters or service pipes, or, in other words, the greater the ability of each consumer to draw on the capacity of the mains, the larger and more expensive must be the street pipes to maintain the service. And in this respect a consumer with a certain size service pipe would entail upon the water works just as much expense whether he used a small or a large quantity of water. Hence, the necessity of a charge, variously designated as "Minimum Rate," "Demand Charge," or "Ready to Serve Charge." Now, the fixed charges, including interest on the cost, depreciation and general administration must go on whether any water is furnished or not, and therefore every consumer should pay a certain amount per year for his water connection, for which he gets no water whatsoever. This we may call a "Ready to Serve Charge." The additional charge must be sufficient to cover all operating expenses.

Per Capita Water Consumption in Metropolitan Water District.—The following tabulation from the 1918 report of the Water Department of Somerville, Mass., shows the daily per capita consumption of water in the cities and towns in the Metropolitan Water District for the year 1918, as registered by the district meters:

City or Town.	Gallons Total per day.	Gallons Per capita per day.	Per cent services metered.
Milton	434,500	47	100
Malden	3,254,700	62	97.29
Medford	2,161,900	62	100
Belmont	577,900	62	100
Winthrop	941,900	65	100
Melrose	1,180,600	66	100
Revere	1,975,500	67	76.98
Chelsea	3,501,200	74	99.81
Arlington	1,290,300	76	100
Swampscott	606,100	76	100
Somerville	7,433,200	80	74.86
Stoneham	617,700	80	99.52
Everett	3,365,800	83	63.06
Lexington	493,700	84	100
Quincy	4,621,700	105	90.16
Boston	94,634,000	120	59.92
Watertown	2,434,500	131	100
Nahant	228,200	149	75.58
Total district	129,753,400	105	72.17

Cost of Water Purification in St. Louis.—During the year ending April 1, 1919, 37,751 million gallons of water were pumped into the basins of the purification plant of St. Louis. To this amount of water were added 1,781 tons of sulphate of iron and 14,999 tons of lime, or an average of 0.66 grains per gallon of the former chemical and 5.56 grains per gallon of the latter. To the 37,675 million gallons of water filtered were added 1,790 tons of sulphate of alumina and 83,160 lb. of chlorine, or an average of 0.66 grains per gallon of sulphate and 2,21 lb. of chlorine per 1,000,000 gal. The sulphate of alumina was added before and the chlorine after filtration. The average cost per million for lime was $3.72, for sulphate of iron $0.82, for sulphate of alumina $1.37, and for chlorine $0.31. These costs are for chemicals alone and do not include the cost of handling or application. The following table from the recently issued report of the Water Commissioner gives a comparison of the costs of the various parts of the purification work done during the past five years, based on the quantity of water delivered to consumers:

COST PER MILLION GALLONS, BASED ON CONSUMPTION.

Old Plant—	1914-15.	1915-16.	Nov., '15, to Apr. '16.	1916-17.	1917-18.	1918-19.
Lime	$1.61	$1.70	$1.61	$1.89	$2.94	$3.72
Iron	2.02	1.42	.64	.61	.57	.82
Unloading	.10	.08	.07	.08	.09	.12
Operating, maintenance and repairs	.35	.47	.51	.38	.41	.60
Water, coal, oil, etc.	.04	.03	.04	.03	.05	.08
Light and power	.03	.07	.07	.04	.10	.12
Chemical work	.25	.43	.49	.38	.34	.30
Basin cleaning	.12	.14	.08	.12*	.17	.22
Basin repairs	....	.03	.03	.01	.02	.02
Total old plant	$4.52	$4.37	$3.54	$3.54	$4.69	$6.00
Filters—						
Aluminum sulphate	....	$0.76	$1.00	$0.79	$1.13	$1.37
Chlorine	....	.18	.15	.14	.27	.31
Operating, maintenance and repairs	....	.83	.98	.80	.77	.89
Coal, miscellaneous supplies and expenses	....	.14	.26	.20†	.36	.29
Light and power	....	.14	.15	.11	.21	.24
Total	....	$6.42	$6.08	$5.58	$7.43	$9.10
Total consumption for year in million gallons	33,971	32,583	13,138	35,633	38,090	36,840
Cost of Chemicals—						
Lime, per ton, average 2 contracts	$ 3.48	$ 3.65	.....	$ 4.49	$ 6.86	$ 8.75
Sulphate of iron, per ton, average	10.00	10.00	.....	12.50	12.84	16.84
Sulphate of alumina, per ton, average	.....	.....	.....	21.00	22.25	27.60
Chloride, per pound	.10	.08	.....	.13⅜	.13⅜	.12⅝

*Water used in basin cleaning—Omitted prior to 1916.
†Water used in filter plant operation—Omitted prior to 1916.

The complete purification system was not in use until October, 1915. The heading, November, 1915-April, 1916, is included to show the costs of purification after the system was completed. The figures are included for the year 1915-1916.

Some Results of Supervision of Public Water Supplies by N. Y. State Department of Health*

By THEODORE HORTON,
Chief Engineer, Division of Sanitary Engineering, New York State Department of Health.

The Engineering Division of the State Department of Health was established in 1906, soon after the old State Board of Health was reorganized into a State Department of Health, with some five divisions or bureaus, of which the Engineering Division is one. When first established, the division staff comprised the chief engineer, one full-time assistant engineer, one part-time assistant engineer and one part-time stenographer. The chief engineer's office was a corner of the health commissioner's conference table, when that was not in use. Today the regular divisional staff consists of twelve full-time engineers and five stenographers, with additional part-time employes for special investigation work. Incidentally, it should be kept in mind, the Engineering Division has many other duties besides those relating to water supplies, including examination and approval of plans for sewerage and sewage disposal, the abatement of important nuisances, supervision of milk pasteurization and investigation and advice relating to stream pollution, garbage disposal, drainage, and other sanitary subjects. The work in connection with water supplies is, however, considered the most important, and approximately one-half of the engineering force is employed almost exclusively upon it.

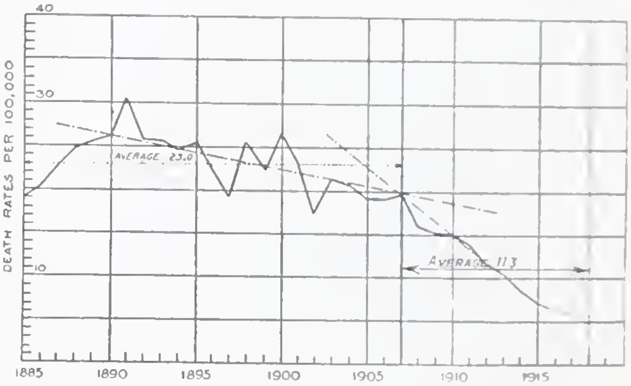
The accompanying chart showing the typhoid fever rate in the state for the past 35 years is almost self-explanatory in regard to its construction; that is, abcissae represent years from 1885 to 1919 inclusive, and ordinates the typhoid fever death rates per 100,000 of population. A glance at the chart shows at once that it may be divided into two general periods, one prior to about 1907, and the other subsequent thereto. The characteristics of the earlier period are:

1. The rates for nearly the entire period are excessive, averaging approximately 23.1.
2. There is a marked lack of uniformity, the curve ascending and descending with considerable irregularity.
3. The range of deviation from the mean is excessive, the curve ascending to a point above 30, in one instance, and below 18, in another.

In contrast with this part of the curve, note the character of the curve for the second period subsequent to 1907, and you will observe:

1. The rates are moderate, averaging for the entire period 11.3, and reaching the low point of 5.4 at the end of the period in 1918.
2. The curve is uniform in character, progressively descending, with only slight deviation at any point from the general direction.
3. The yearly rate of change at the latter end of this period is very much less than the rate of change at the beginning of the period; indicating that the limit of reduction of mortality from typhoid fever in the state has begun to be reached.

Now the question which naturally arises after glancing over this curve is, what influence or changes in condition began to be exerted at the beginning of the period, ranging from 1906 to 1919, that might rationally account for the subsequent rapid and uniformly downward trend of this curve and the comparatively very low rate reached in the year 1918? The answer, it seems to me, is largely in the fact, that in 1906, following a reorganization of the old State Board into a State Department of Health, a new force or agency was added to the resources of the department in the nature of an engineering division, one of whose specific duties was the investigation and supervision of public water supplies. Prior to the establishment of the engineering division comparatively little attention, and no systematic activities, were directed toward the improvement of public water supplies in the state. Many of these water supplies had alreday been introduced, but up to that time the close relationship between the quality of public water supplies and typhoid fever incidence seemed not to have been fully realized by the communities of this state generally, nor were the principles of the art of water purification and sewage disposal well understood. This fact is somewhat startling when we consider that this knowledge and relationship were well recognized by sanitarians and by some state health authorities, as for instance, in Massachusetts, where public water supplies were under excellent supervision, and were generally of good quality, and where the typhoid fever rate in the state was much lower than in this state. It is of particular interest to note, however, that almost simultaneously with this extension of the organization and scope of the New York State Department of Health at this time, and especially the establishment of the Engineering Division, equipped with scientific knowledge and facilities for systematically studying and investigating public water supplies, we find a very marked increase in public interest concerning the sanitary quality of public water supplies. This was clearly evidenced by a general demand for investigations; by a pronounced willingness by municipalities to heed our advice; and by an almost immediate decline in the typhoid fever rates throughout the state—a decline that has uninterruptedly continued up to the present time.



Typhoid Death Rates in New York State.

Beginning with the year 1906, the engineering division started a series of special investigations of certain public water supplies, selected with special reference to high incidence of typhoid fever. A year or two later these special investigations were made a part of the routine work of the division. The yearly returns from this work, in terms of lowered typhoid fever rates, so clearly demonstrated its value, that in each succeeding year more attention was given to this part of our work. It remained, however, for our present commissioner, Dr. Hermann M. Briggs, to fully appreciate the great value of this sort of life-saving work and to foresee in it a great opportunity for lowering the general death rate of the state. In fact, almost immediately upon assuming office, Dr. Biggs directed that the principal work of the Engineering Division should be the investigation and supervision of public water supplies, and that this work should be prosecuted until all of the water supplies in the state shall have been investigated and improved, and the mortality rate from this source reduced to a minimum. It is needless to say that this policy is still in force, and the present low typhoid rate indicates that these aims of our commissioner have already been largely realized.

The speaker will cite briefly a few figures showing the progress that has been made during the past 12 years in the development and improvement of public water supplies in the state. In 1906 there were in round numbers some 400 public water supplies in the state, serving a population of about 6,100,000 persons. Of these supplies about 50, serving a population of 700,000, received some sort of treatment, either by slow sand or mechanical filtration. In 1919 there are approximately 530 public water supplies in the state, serving a population of approximately 8,500,000. Of these supplies about 130, serving a population of approximately 6,900,000, are treated either by filtration or chlorination. This means that in the 13 years, from 1906 to 1919, the number of people supplied with public water supplies had increased from 6,100,000 to 8,500,000, or approximately 40 per cent; while in the same period the number of people protected by water purification in some form had increased from 700,000 to 6,900,000, or an increase of almost 1,000 per cent.

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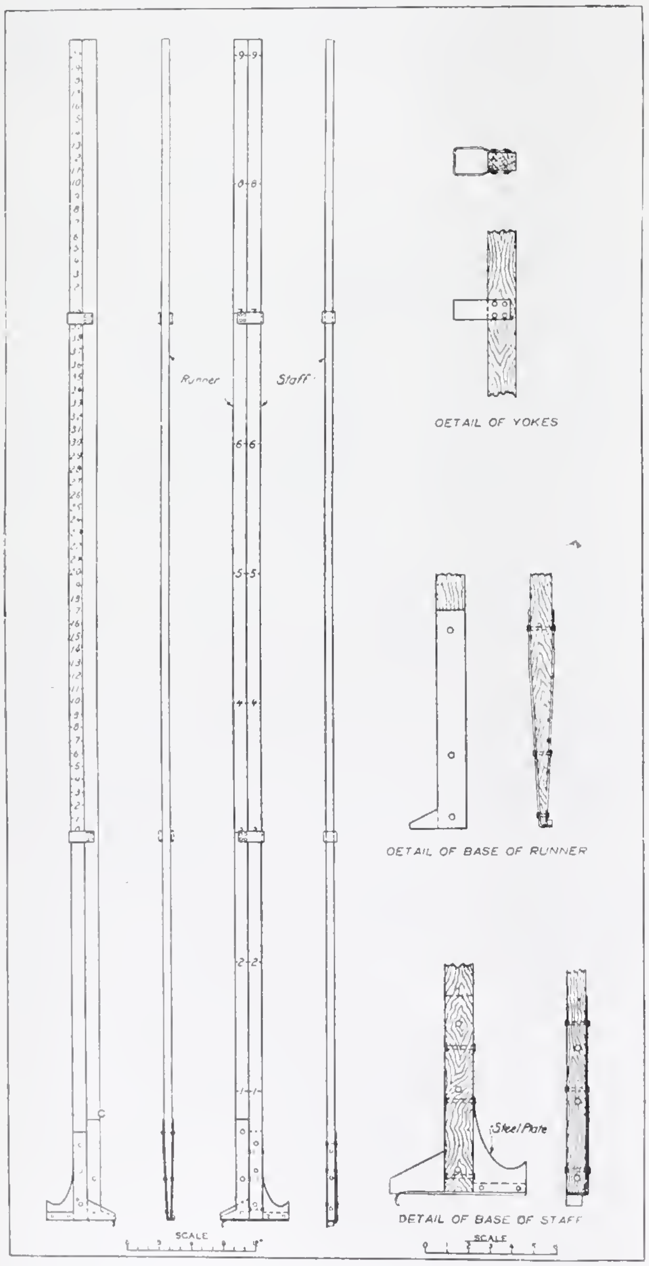
*Abstract of paper presented at the convention of the New England Waterworks Association, held Sept. 30-Oct. 3, in Albany, N. Y.

Sounding Rod for Canal and Stream Measurements

In the September Reclamation Record Mr. W. G. Stewart, Assistant Engineer, U. S. R. S., describes a useful sounding rod developed by him and his assistants. The main use of the rod is in getting the soundings in the cross section at a measuring station, but it is also useful as a hook for cutting weeds or grass, or for removing trash from headings, bridge piers, or trash racks. It serves as a measuring stick for laying off sections at a station, or the staff can be placed across a narrow stream while the meter is operated along it by use of the runner, thus saving the time and trouble of making a wading measurement. It has sufficient length and strength to be used as a vaulting pole for jumping narrow canals. It will serve very well for a leveling road where close work is not required.



Details of Sounding Rod.

The diagram shows the road with its various markings and also the detail construction of the yokes and the bases of the staff and runner.

The staff and runner should be made of 1 by ½ in. tough, straight-grained wood. This is essential because the strain to which the rod is subjected in practical use, especially in swift, deep canals, is severe, to say nothing of its use as a brush and trash hook. The yokes must be made full enough to allow the runner free play along the staff so that it can be quickly and easily moved when making soundings.

All markings on the rod should be cut into the wood with a smal gouge or carving tool. This rod should have at least two coats of best white paint and the markings should be made with black paint, which should be applied before the last white is entirely dry. As the upper edges of the yokes are used as indices they should have black lines along these upper edges to avoid any confusion in reading.

The lower end of the staff should have cross rivets to prevent splitting. The metal on the bases of staff and runner is No. 16 gauge galvanized sheet iron such as is used for weir crests. The steel cutter is made from a piece of heavy hand saw or shovel blade. This steel cutter is riveted to the base before mounting.

The small hook shown at the bottom of the base is formed by turning down the foot plate and is used to hold the rod to the bottom of the section, where the water is deep and swift, and the bottom is of hard, smooth material like concrete or rock. The base is made large so as to get more nearly the mean elevation of the surface of the stream bed. Too much emphasis can not be put on the necessity of making all parts strong and mounting them securely.

When making a sounding the base of the runner is allowed to skim the surface of the water, while the base of the staff rests on the bottom of the stream. When the depth is 2 ft. or less the reading may be taken from the top of either the upper or lower yoke as may be most convenient. When the water is over 4 ft. deep any reading on the upper 2 ft. is added to 4 ft. Where the water is over 6 ft. deep, then 3 ft. is added to the figures opposite the base of the runner.

Operation of Slow Sand Filters at Toronto for 1918

Ten thousand samples tested during the year 1918 at the Toronto slow sand filters showed an average reduction of 99.7 per cent in B. Coli, 99.1 per cent in total bacteria and 99 per cent in excremental bacteria. A report on the operation of this plant has been made the subject of an article which recently appeared in the Canadian Engineer and from which the following notes have been extracted:

The city of Toronto is supplied by two modern filtration plants, one a mechanical plant of the drifting sand type and the other a slow sand system. The mechanical plant is being made the subject of a special report.

The following summary shows definitely what the slow sand plant is accomplishing:

(1) Over 10,000 samples were examined from the slow sand filter system during the year.

(2) The average number of bacteria growing on agar at blood temperature was 356.3 per c. c. in the raw water and 2.2 per cc. in the filtered water. Total reduction, 99.1 per cent.

(3) The average number of excremental bacteria growing on bile-salt agar at blood temperature was 26.5 per cc. in the raw water and 0.25 per cc. in the filtered water. Reduction, 99.0 per cent.

(4) The total percentage of samples showing B. Coli in 1 cc. was 39.9 in the raw water and 0.66 in the filtered water.

(5) The average indicated number of B. Coli present per 100 cc. of water examined was 1,136 in the raw water and 2.7 in the filtered water, showing a total reduction of 99.7 per cent.

(6) Pollution of the raw water as judged by the B. Coli test has increased 61.9 per cent since 1913.

(7) The highest temperature recorded in the water was 64° F. and the lowest 33.9° F.

(8) The highest degree of turbidity in the raw water was 160 parts per million and the lowest was 1. The filtered water was free from any turbidity throughout the year.

(9) The chlorides in the raw water were 8.2 parts per million in 1913 and 9.89 parts per million in 1918.

(10) The total number of filters cleaned was 181. The average rate of filtration was 3.27 million Imperial gallons per acre per day. The average amount of water filtered was 31.42 million Imperial gallons per day, or 50 per cent of the average daily consumption. The maximum and minimum daily consumption during the year was 77.49 and 45.61 million Imperial gallons per day. The average daily per capita consumption was 128 Imp. gal.

Cost of Constructing Sewers and Water Mains at Montreal South, Que.

During 1918 about 22,230 ft. of 6-in., 8-in. and 10-in. water main, and 25,300 ft. of 24-in., 12-in. and 9-in. sewer were constructed for the town of Montreal South, Que. The work was done by contract, and the following figures are the actual cost to the contractor. The contractor, by the way, made no profit.

The sewer work covered the construction of mains in 17 streets. The material in which the trenching was done consisted of hard pan at the surface, a layer of shale, a bed of trap rock 3 to 5 ft. thick at 5 to 8 ft. from the surface, and shale below the trap rock. The rock excavation was paid for at the rate of $4 per cubic yard over the other material. The rates of pay for labor were as follows:

	Per hour, ct.
Common labor	35
Pipe layers	37½
Drillers	40
Blacksmith	40
Foreman	45
Single horse and driver	40
Double team	70

The unit costs on four jobs were as follows:

	Job No. 1. 24-in. sewer, per lin ft. of sewer.	Job No. 2. 12-in. sewer, per lin. ft. of sewer.	Job No. 3. 12-in. sewer, per lin. ft. of sewer.	Job No 4. 9-in. sewer, per lin. ft. of sewer.
Materials:				
Pipe	$1.800	$0.590*	$0.580*	$0.370*
Cement and oakum for joints	.160	.052	.052	.040
Manholes†	.270	.290	.246	.218
Coal and oil	.015	.012	.012	.009
Total material	$2.245	$0.944	$0.890	$0.627
Labor:				
Cartage	$0.065	$0.050	$0.050	$0.027
Excavation and pipe laying	1.755	1.940	1.850	1.590
Rock, extra	1.947	2.082	1.265	1.006
Back filling	.717	.624	.605	.515
Total labor	$4.484	$4.696	$3.770	$3.138
Grand total, material and labor	$6.729	$5.640	$4.660	$3.765

*Pipe and branches. †Brick with concrete bottom and cast iron cover, cost $70 each.

Job No. 1 consisted of 1,780 ft. of 24-in. vitrified pipe sanitary sewer with 7 manholes. The average cut was 9½ ft. in hard pan, shale and trap rock. The total excavation was 2,350 cu. yd. with 867 cu. yd. of rock extra.

Job No. 2 consisted of 2,970 ft. of sanitary sewer, 107 6-in. branches, and 12 manholes. The average depth was 10 ft. in hard pan, shale and trap rock, with the latter close to the surface in places and varying 3 to 5 ft. in thickness between shoals. The total excavation was 3,260 cu. yd. with 1,550 cu. yd. of rock extra.

Job No. 3 consisted of 11,650 ft. of 12-in. sanitary sewer laid in five streets, 296 6-in. branches, and 41 manholes. The average cut was 8½ ft. in hard pan, shale and trap rock.

Job No. 4 covers 8 to 10 ft. of 9-in. sanitary sewer on nine streets with 284 6-in. Y-branches, and 27 manholes. The average cut was 8 ft. in hard pan, shale and rock.

Owing to the direction of veins in the rock, practically the whole of the work was done by hand except the heavy fill on backfilling, which was done by steam tractor shovel.

The water main construction involved the laying of 3,560 ft. 10-in., 7,070 ft. of 8-in., and 11,600 ft. of 6-in. Class C cast iron pipe. All the materials except the valves were imported from the United States. Cast iron pipe and fittings cost $46.00 per ton (2,000 lb.) on car Philadelphia. Freight and duty brought the cost to $77.00 per ton on car 2 miles from line of work. The rates of pay for labor were as follows:

	Per hour, ct.
Common labor	30
Pipe layers	35
Foreman	40
Single horse and driver	40
Double team	70

The following figures represent materials and laying pipe and not excavation, as the work was done under separate contract during the laying of sewers. The sewer contract providing for the back filling over the sewer pipe to the depth of 1 ft. to allow the water main to be laid, the [illegible] contractor completing the backfilling.

Materials	10-in. main per lin. ft. of main	[illegible] per [illegible] ft. of main	[illegible] per lin. ft. of main
Pipe	$2.747	$[illegible]	[illegible]
Gate valves and boxes	.109	.111	[illegible]
Hydrants[1]	.109	.11[illegible]	.1[illegible]
Leadite[2] and coal oil for heater	.080	.067	.051
Total materials	$3.045	$2.[illegible]	$1.[illegible]26
Labor:			
Cartage from cars to line of work	$0.035	$0.025	$0.027
Grading trench, pipe laying, packing pipe in trench, testing	.437	.378	.2[illegible]
Total labor	$0.472	$0.403	$0.296
Grand total labor and material	$3.517	$2.710	$1.922

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[1] 6 10-in. double gate valves and boxes at $65 each, and 6 6-in. balance valve hydrants (6 ft. fill) at $65 each, with 10-in. main, 19 8-in. double gate valves and boxes at $41.50 each and 13 6-in. balance valve hydrants at $65, with 8-in. main, 22 6-in. double gate valves and boxes at $31.50 each, and 22 6-in. balance valve hydrants at $65, with 6-in. mains.

[2] Leadite at 20 ct. per lb.

[3] Cartage at $1 per ton.

Ernest Drinkwater, Montreal, Que., was consulting engineer for the town of Montreal South, Que.

13½ Ft. Wood Stave Pipe Used in Ontario Power Company's Extension

The Ontario Power Co., of Niagara Falls, Ont., has recently completed an extension to its plant which will increase the capacity by 40,000 to 50,000 hp. One of the unique features about this addition is the use of a 13.5 ft. diameter wood stand pipe which is one of the largest ever built. Another unusual feature is the differential surge tank. It has the greatest diameter and height of any similar tank not equipped with an auxiliary spillway.

A rather complete description of this plant appeared recently in The Contract Record and the following notes are of interest:

The construction of this extension involved the excavation of 133,000 yd. of earth and 14,000 yd. of rock to permit the placing and erection of a 13.5 ft. diameter wood stave pipe 6,700 ft. long, a 13.5 ft. diameter steel distributor 179.5 ft. long, a 60 ft. diameter steel differential surge tank 94 ft. high, four Johnson hydraulic operated valves, two 10.5 ft. diameter penstocks and two 20,000 HP. turbines with direct connected generators, also the erection of the additional power house to house these units.

No. 3 conduit, the one recently constructed, is 13.5 ft. inside diameter. The staves are of B. C. fir 4 in. thick by 6 in. wide and banded with ⅞ in. diameter steel bands, in two sections with two shoes. The pipe is carried on timber saddles spaced on 4½ ft. centers except where the pipe is concreted in place. Connection is made with the 20 ft. diameter thimble at the gatehouse by means of a reinforced concrete reducer 25 ft. long. The connection between the wood stave pipe and the concrete reducer is made by means of another steel thimble 13.5 ft. in diameter and 6 ft. long. This thimble, which projects 2 ft. from the concrete reducer, extends 1½ ft. into the wood stave barrel. Connection with the surge tank and penstocks is made by means of a steel distributor, 13.5 ft. in diameter and 179.5 ft. long. The saddles used to support the pipe are built-up timber sections and are so constructed as to make a continuous form for the lower half of the pipe. Mud sills were used through the earth cut and omitted in the rock cut.

The excavation for the trench for the wood stave pipe was handled from the cut by shovels, derricks and locomotive cranes. A portion of the excavation was deposited along the sides of the cut for back-fill while the remainder was placed on dumps located at convenient points.

The capacity of the wood stave conduit is 2,750 cu. ft. per second, giving a velocity of 19.2 ft. per second based on C = 135 in the Hazen and Williams formula. Under such conditions there will be a total loss in the conduit, from gate house to penstock, of 32 ft. Under such conditions the capacity of the pipe will be approximately 45,000 turbine hp. With a co-efficient of C = 150, which is within the limits of possibility, and the same total loss of 32 ft., the discharge capacity would be 2,930 cu. ft. per second with a velocity of

20.5 ft. per second and would give approximately 48,000 turbine horse-power.

A co-efficient of roughness of 100 was used in figuring the losses in the steel penstocks. The use of this co-efficient was based on the results of tests on the other penstocks.

The surge tank is of the Johnson differential type, 60 ft. outside diameter and 78 ft. high. The tank is built of steel plate varying in thickness from ¼ in. plate at the top to 1 in. plate at the bottom, while the internal riser, 12 ft. in diameter and 60 ft. high, is built of ½ in. plate. The roof for the tank is constructed of steel roof trusses with wood covering. Anchors with turnbuckle connect the trusses with the riser to prevent vibration during load changes. The steel bottom of the tank is constructed of ½ in. flat plates, field riveted, resting on a carefully leveled 2 in. grout course spread over a thin concrete footing poured on the solid rock.

The water wheels are double runner, central discharge turbines with spiral casings, running at 187.5 r.p.m. and delivering 20,000 hp. under 180 ft. head. The turbine gates are operated by vertical servo-motors which are controlled by actuators mounted on the gallery. These actuators are equipped with distance speed controllers, hydraulic hand controllers, gate limiting device, manual speed adjuster, gate opening indicator and tachometer. The pressure oil for operating servo-motors is furnished by a helical gear rotary pump, delivering 62.5 gal. per minute against 200 lb. pressure. The sump tanks are each of 350 gal. capacity and are provided with screens for cleaning the oil before it is returned to the pressure tank.

The new construction was carried out under the direction of the technical staff of the Hydro-Electric Power Commission of Ontario, of which Sir Adam Beck is chairman and F. A. Gaby is chief engineer.

Tests of Paints for Interior Surface of Iron Standpipes

Comparative tests of various paints used in painting the inside of an iron water tank are summarized in a paper presented last week at the 36th annual convention of the New England Water Works Association by Charles W. Sherman, of Metcalf & Eddy, consulting engineers, Boston. The experiments were made by Mr. A. H. Keen of Philadelphia and consisted in painting two standpipes with vertical stripes of different kinds of paint and observing the conditions after two or three years' service. Mr. Keen's report, which is given as an appendix to Mr. Sherman's paper, is as follows:

> To obtain better information as to a suitable paint for protecting iron under water, the writer decided to paint the inside of a standpipe with different paints, for experimental purposes.
>
> The first samples were applied in August, 1909, the iron being carefully cleaned with wire brushes, and loose scale chipped to clean iron.
>
> Our experiments have been applied particularly to the inside of the tank, as we have found that the outside can be protected by a good lead, iron oxide or graphite paint, which, if of proper quality and properly applied, will protect the iron for at least 5 years, unless subject to unusual conditions. Usually the appearance of the outside will call for painting before the necessity.
>
> In 1910 a smaller tank than the first one used for experiments was erected, and this was painted on the inside with differnt paints, and is still being used for experimental purposes, as it is more accessible than the first.
>
> The kinds of paint applied to the two tanks, and the results found by inspection, are listed in Tables I to IV—Tables I and II covering the first tank, and Tables III and IV covering the second tank. The names of manufacturers of the various paints used have been omitted.

TABLE I.

Tank 40 ft. in diameter by 50 ft. in height. Samples about 25 ft. in width by 50 ft. in height.

Kind of paint. Two coats. Date applied, August, 1909.	Condition. Date of inspection. Tank half full of water, April 27, 1911.	Tank empty. September, 1912
1. Iron oxide	Good	Fair
2. Iron oxide	Bad	Bad
3. Graphite—black	Bad	Bad
4. Asphaltum—black	Very bad	Very bad
5. Portland cement (brushed on)	Very bad	Very bad

TABLE II.

Same tank as Table No. 1. Samples about 8 ft. in width by 50 ft. in height.

Date applied. September, 1912.	Date of inspection. Tank half full, May, 1914.	Tank empty, May, 1916.
1. Oxide of iron—red	Very good	Very good (best)
2. Oxide of iron—black	Very bad	Fair
3. Tar base—black	Very bad	Very bad
4. Oxide of iron—red	Fair	Bad
5. Oxide of iron—red	Fair	Bad
6. Pitch—black	Very bad	Very bad
7. Graphite—carbon	Very bad	Fair
8. Graphite—carbon	Very bad	Fair
9. Oxide of iron—red	Fair	Good
10. Car. coating—black	Good	Very bad
11. Oxide of iron—red	Fair	Fair
12. Oxide of iron—red	Fair	Bad
13. Oxide of iron—red	Very bad	Bad
14. Tar—black	Very bad	Very bad
15. Red lead, first coat; metallic brown, second coat	Good	Good
16. Flexible tank, oxide of iron—red	Good	Good

Repainted May, 1916, with iron oxide paint, and experiments discontinued.

TABLE III.

Tank 30 ft. in diameter by 39 ft. in height. Samples about 16 ft. wide and 39 ft. high. Painted May, 1910.

Paint two coats.	Condition. Date of inspection. Tank half full of water, February, 1911.	Tank empty, September, 1914.
1. Graphite	Bad	Bad
2. Rubber paint	Bad	Bad
3. Oxide of iron—red	Good	Very good
4. Oxide of iron—red	Bad	Bad
5. Red lead (1), metallic brown (2)	Fair	Good
6. Oxide of iron—red	Good	Bad

TABLE IV.

Same tank as Table III, repainted on inside, September, 1914. Twelve samples about 8 ft. by 39 ft. in height.

Kind of Paint—Two coats.	Inspected December 26, 1916. Tank half full of water.
1. Oxide of iron—red	Good
2. Pitch—black	Bad
3. Oxide of iron—red	Bad
4. Asphalt and Portland cement	Bad
5. Red lead, first coat; metallic brown, second coat—brown	Very good
6. Red lead lute, first coat, metallic; second coat, brown	Bad
7. Oxide of iron—red	Bad
8. Tank paint, pitch—black	Bad
9. Tank paint, oxide of iron—red	Bad
10. Roof coating—pitch—black	Bad
11. Tank paint—oxide of iron—red	Good
12. Sticktite No. 3 pitch (black)	Bad

> Samples marked "Good" and "Very good" had comparatively few tubercles on surface and no scaling or blistering. Samples marked "Fair" had more tubercles and some scaling and blistering. Samples marked "Bad," the surface was fairly well covered with tubercles and some blistering and separations had taken place. Samples marked "Very bad," the surface was generally covered with tubercles and the paint badly scaled and very badly blistered. In the painting of September, 1914, the red lead and metallic brown paint used was mixed on the ground by our chief painter and the best quality of everything was used.

In commenting on the report Mr. Sherman states:

"The only paints which gave reasonably good service were a red oxide of iron paint, and red lead.

"Most of the paints used were undoubtedly proprietary articles, and although one red oxide of iron paint showed 'good' or 'very good' results, several others characterized the same way in his tabulation gave 'bad' or 'very bad' results. It is to be noted, too, that red lead when used was employed only in the first coat, yet the results were characterized as 'good' or 'very good.' It is not impossible, therefore, that two or three coats of red lead would have shown better protection than any of the other paints."

Typhoid Death Rates in 1918.—The annual survey of the Journal of the American Medical Association of typhoid death rates in American cities of more than 100,000 population, shows that in 1918 22 first class cities out of the 60 covered by the report have rates under 5 per 100,000. These cities were:

Chicago	1.4	Springfield, Mass.	3.6
Lowell, Mass.	1.8	Camden, N. J.	3.6
Rochester, N. Y.	1.9	New York	3.7
Paterson, N. J.	2.1	Bridgeport, Conn.	3.9
Seattle	2.3	Cincinnati	4.1
Boston	2.5	Jersey City	4.1
Cambridge, Mass.	2.7	Providence, R. I.	4.5
Los Angeles	2.8	San Francisco	4.6
Philadelphia	3.0	Worcester, Mass.	4.6
Newark, N. J.	3.5	Oakland, Calif.	4.7
St. Paul	3.5	Cleveland	4.9

Union Wages for San Francisco City Draftsmen.—The Board of Public Works of San Francisco has approved the recommendation of City Engineer M. M. O'Shaughnessy that the union wage scale be granted to draftsmen, surveyors, inspectors and others in the city engineer's department who belong to the newly organized engineer's union. One hundred men in the city engineer's department are affected. The additional appropriation to meet salary increases will amount to $77,000 a year.

MANAGEMENT AND OFFICE SYSTEM

This section is published twice a month: (1) In the Waterworks and Hydraulic Monthly issue, and (2) in the Railway and Excavation Monthly issue. It covers what may be broadly termed "management engineering" as applied in the civil engineering and construction fields.

The Managerial Law of Inspection and Constructive Criticism, with Special Reference to Waterworks

By HALBERT P. GILLETTE, Editor.

In scientific management there is a principle that may be called the law of inspection and constructive criticism. To secure maximum economy all work must be systematically inspected and analytically studied by an impartial critic, and the results of the inspection must be made known to the worker.

This rule is violated to some extent in nearly every organization, but nowhere more often than in municipal governments. Take, for example, the water works departments of cities. The plant is designed and operated by men whose work is rarely given a critical review by disinterested, competent critics. As chief executive the mayor should either perform this critical function or delegate it to some one to perform; but how often does he do so? The president of a water works company is usually rather alert in watching operating methods and costs, and to that extent is a constructive critic, but he usually lacks engineering knowledge and is, therefore, not a competent critic of the design of the plant. In most cases he trusts entirely to an engineer or a superintendent whom he employs, and to that extent he violates the law of management above given; for the engineer or superintendent who is responsible for the plant design is not a disinterested critic of the design. Of course he is prejudiced in his own favor, and believes that he has designed an economic plant.

Fortunately, we are in a position to establish conclusively the fact that the design of most water works plants is susceptible of improvement, for it happens that there exists an organization whose business it is to inspect such plants, and the inspections thus far reported show invariably many defects of design. We refer to the Committee of Fire Prevention and Engineering Standards of the National Board of Fire Underwriters, 76 Williams St., New York City. Mr. George W. Booth is chief engineer of this committee. Elsewhere in this issue we have abstracted from his Report No. 151 certain constructive criticisms of the city water works of Fort Wayne, Ind. In reading those criticisms bear in mind that Mr. Booth's sole object was to indicate wherein the water works plant is defective for fire protection purposes. Had he reported on economic defects of all sorts, can there be any doubt that he would have discovered a much greater number?

The public service commissions of different states, notably Wisconsin, have repeatedly pointed out economic defects in many water works departments, such, for example, as inadequate maps and construction records. They have also shown that accounting records are often woefully primitive. So frequently have such defects been mentioned that there can be little doubt that not a water works department exists in America that would not be benefited by the criticism of a disinterested hydraulic engineer. The writer has appraised a number of water works, and in every case has seen gross errors of design and operation. He has talked with many other appraisers whose experience has been the same.

It should not be inferred that water works departments are worse than any other municipal departments. They are probably all equally susceptible of improvement. Nor should it be inferred that private corporation management is free from defects. There are altogether too many executives in every branch of every business who fail to apply the law of inspection and constructive criticism. How often, for example, is the location of a railway line carefully reviewed and criticised by a consulting railway engineer? The question is quickly answered upon seeing how very few engineers specialize as railway consulting engineers. Indeed, the total number of consulting engineers of all kinds is so small as to show the scant respect that now exists for the law of inspection and constructive criticism.

It is natural that an engineer or superintendent should not invite a critical review of his own work, for if he is a capable man he feels great confidence in his own performance, and if he is not capable he shuns criticism. Executives dislike to insist upon having a disinterested criticism of the work of heads of departments, for fear of creating the impression that they lack confidence in those heads. Nevertheless, they expect those very heads to be critical of the work of their subordinates. Perhaps much of the opposition to constructive criticism of "the higher-ups" would vanish were it more generally realized that scientific knowledge in every specialty has far outgrown the capacity of any single brain, no matter how studious and retentive that brain may be. Greater clarity of thinking would result were it also generally realized that all the indexes of technical literature are so defective as to be untrustworthy in any exhaustive search for data. It is often said that a technical man's knowledge is of two kinds, that that he knows, and that that he knows where to find. The inference is that any well-trained man can readily find all necessary information on anything that he can not remember; but it can not ordinarily be done. The result is that two engineering heads are invariably better than one, if both have had an equal number of years of experience in the same specialty and have been equally studious. Hence it follows that no engineer, however brilliant in mind or broad in experience, can logically resent having his work reviewed by an independent specialist. Indeed, every conscientious engineer should not only welcome such a review of his work, but should request it. I am not speaking merely of subordinates but of the men at the heads of departments. And of course what is true of engineers is true of every class of men engaged in designing or operating plants.

The incentive of profits usually leads the owners of private plants to do a good deal of constructive criticism of their executives, and a very wholesome thing it is for any business. But this incentive is lacking in government; hence the peculiar need of creating departments whose sole function is to criticise. "Efficiency bureaus" have been established in a few cities. Every city should have one. In addition, consulting engineers and efficiency experts should be called in periodically from the outside, and many other steps should be taken to secure the benefit of the knowledge of several specialists in solving every important economic problem.

Repairing Leaks in Service Pipes.—An ordinance was passed last year by the city council of Harrisburg, Pa., requiring that all leaks or breaks in service pipes be repaired by the owners or occupants of the premises supplied within 72 hours after notice from this department; providing a penalty for failure to do so; authorizing the department to make the necessary repairs in certain cases and to collect the cost thereof from the owner or occupant of the premises, and also authorizing the department to cut off the water supply until the repairs are made or paid for. This ordinance was intended to do away with the constant supervision usually needed when leaks had been reported by the inspectors and to set a definite time for necessary repairs to be made.

Cost of Engineering Work for Maintenance and Operation of Large Irrigation Project

By H. M. CHADWICK,
Assistant Chief Engineer, Valier-Montana Land & Water Co.

The Valier Project is a 130,000 Carey acre irrigation project, located in Pondera County in northwestern Montana. A portion of the project has been in operation since 1912. In 1914 the original construction work was furnished, and by 1916 colonization had progressed to such an extent that maintenance and operation activities occupied by far the majority of time spent by the Engineering Department. Much addition and betterment work developed later in the season. All engineering work since 1915 has been done from Valier, Mont., the field parties using Ford cars with delivery bodies as the means of transportation.

The engineering work connected with the operation and maintenance of a large irrigation project consists of many different classes, no single piece of work is likely to be of much magnitude from a standpoint of size, except in the case of a large addition and betterment job. This condiiton makes it necessary for the field parties to jump here and there over the project, and take up sometimes three or four different classes of work a week. The proposition of obtaining unit costs under these conditions is rather more difficult than during construction days when a field party would be occupied for weeks at a time on one class of work.

An engineering order system was evolved whereby each job is covered by an engineering order, showing a number, the canal, reservoir, structure or land involved, the class of work, and the information regarding the necessity for the survey. This order is then given the chief of party, who consults the records, referring to the original construction, or the original land classification survey, as the case may be, and obtains all data bearing on the case. After completing the field work, the field salary cost is placed upon the order and turned to the drafting room. After its passage through the drafting room it contains the additional costs accrued, and finally emerges as a statement of the work performed, all references thereto, and the salary costs. At the end of the month the proportionate amount of engineering expense, transportation and overhead is pro-rated to each order to obtain the grand total cost of the job.

A monthly cost distribution and time sheet was designed to better enable the men to distribute their time to the proper classifications. The chief of party is supplied with time sheets for each man, as is also the office engineer for his men. These sheets show the number of each engineering work order, its classification and the time and portion of the salary chargeable thereto. The usual field party consists of four men, namely, the chief of party, instrumentman, one rodman, and one chainman, the rodman acting as a chainman while making measurements.

A large amount of the work covered by engineering orders is of such a nature that it would be difficult to divide it into units. Only those costs actually incurred and chargeable against the units are used. There remains, therefore, a good proportion of the yearly payroll which is not applicable to work involving units.

The construction of new structures and new canals is considered as addition and betterment work; this, and the yearly maintenance work on canals and structures is done by company outfits under the direction of the superintendent of maintenance. Estimates of material needed, detailed plans and the necessary information as to location, etc., of the staked structure or the canal staked for cleaning are furnished by the engineering department to the superintendent of maintenance. Reports of materials used are furnished by the foreman in charge and much of the inspection is done by the superintendent of maintenance.

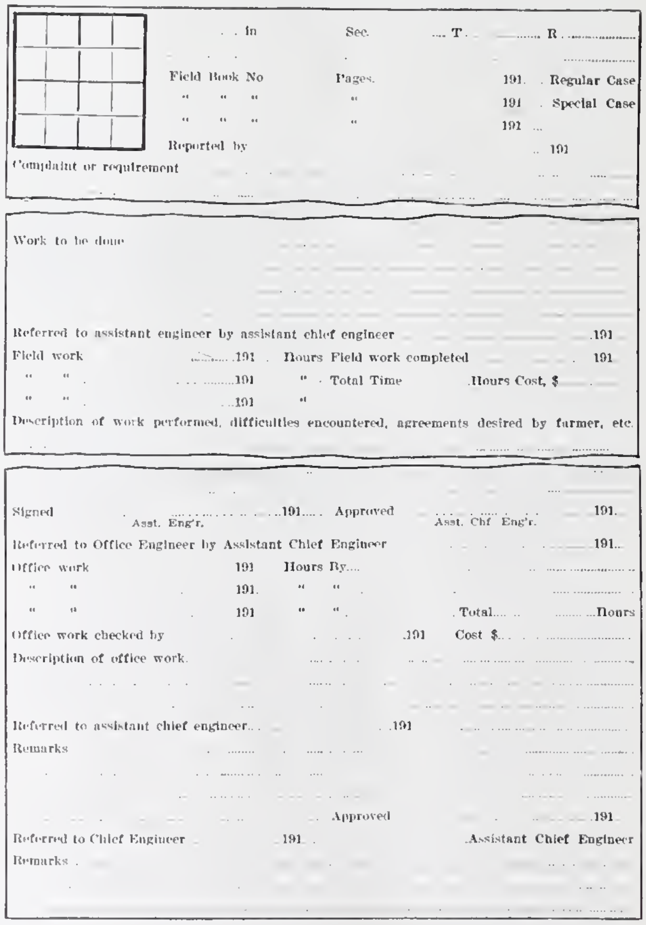
The following tables give the unit costs for the years 1916, 1917, 1918, and the salaries of the men who performed the work. There is also given the computed percentage of the salary cost occupied by the cost of transportation, engineering expense, and overhead. This percentage, when added to the salary costs, gives the total cost of the work, and is so represented by the unit costs as shown.

MONTHLY SALARIES OF ENGINEERING FORCE.

	1916.	1917.	1918.
Chief of party	$120	$150	$160
Instrumentman	90	130	140
Rodman	80	105	100
Chairman	80	90	90
Office engineer	..	150	160
Draftsman	100	130	150
Drillman	...	130	130
Helper	...	120	120

The cost of transportation, all engineering expense and overhead was 44 per cent of salary costs in 1916; 50.1 per cent of salary costs in 1917 and 47.7 per cent of salary costs in 1918.

The item of auger holes mentioned in the unit costs for 1917 covers the boring with 6-in. augers in a soil composed of loam, clay and some sand. Some of these holes were


In Sec. T. R.
Field Book No Pages. 191. Regular Case
" " " " 191 Special Case
" " " " 191
Reported by 191
Complaint or requirement

Work to be done

Referred to assistant engineer by assistant chief engineer 191
Field work 191 Hours Field work completed 191
" " 191 " Total Time Hours Cost, $
" " 191 "
Description of work performed, difficulties encountered, agreements desired by farmer, etc.

Signed 191 Approved 191.
Asst. Eng'r. Asst. Chf Eng'r.
Referred to Office Engineer by Assistant Chief Engineer 191
Office work 191 Hours By
" " 191. " "
" " 191 " " Total Hours
Office work checked by 191 Cost $
Description of office work.

Referred to assistant chief engineer 191
Remarks

Approved 191
Referred to Chief Engineer 191 Assistant Chief Engineer
Remarks

Engineering Work Order Form; Actual Size 6x11 In.

The duplicate of the engineering order showing the results of the survey, the office work, and the advice of the engineering department regarding the work, and to which are attached the necessary plans and bills of material, is given to the maintenance department by the assistant chief engineer. From the data contained thereon a construction work order is issued by the maintenance department, which must contain the signature of the chief engineer, as authority for the expenditure. The construction work order is then given to the foreman, to whom the job is assigned.

UNIT COSTS OF ENGINEERING WORK.

Classification.	Unit.	Cost in 1916 Number of units.	Cost in 1916 Unit cost.	Cost in 1917 Number of units.	Cost in 1917 Unit cost.	Cost in 1918 Number of units.	Cost in 1918 Unit cost.
Canal grades	Mile	19.48	$6.28	199.89	$16.38	46.05	$17.61
Highland	Acre*	1,640	.166	4,840	.198	11,600	.177
	Acre credit	234.37	1.16	255.64	3.78	852.82	2.42
Small structures	Structure	61	3.11	32	4.67	389	5.54
Fence lines	Mile	12.75	4.90	17	8.57	17	12.42
Farm laterals	Mile	18.60	5.38	28.93	14.96	211.55	6.15
New laterals	Mile	.....	....	1.5	32.38	4.2	66.93
Auger holes	Feet	.....	....	1,261	.50	...	.....
Drill holes†	Feet	.....	....	....	.....	202	2.34

*Acre of gross acreage involved. †Calyx core drill holes.

bored to a depth of 20 ft. by using a tripod derrick to steady the pipe when the auger was withdrawn with its load.

The item designated as calyx core drill holes in unit costs for 1918 covers work done to determine the nature of various strata and the position of the water table. These holes were drilled with a type G. O. calyx core drill which is sold as a hand driven drill, but which was connected up with a gasoline engine. This drill has a 2½-in. bit. The material encountered was clayey loam top soil, gravel and finally cement gravel. The nature of the material precluded any speedy progress. The maximum depth drilled was 18 ft.

The item designated as highland consists of a survey to determine the classification of land, as to irrigable, high, waste, meadow, and grazing. Since the original classification was made in 1911 and 1912, all later surveys are in the nature of a check on the original work and revisions thereof. It is necessary to assemble all the original data, investigate the ground, possibly retrace a portion of the old survey, run the highland boundary ditches, establish boundaries of the land classified as waste, meadows, etc., and make a transit location of same, after which the work is plotted up and the revision noted on all records.

It will be noted that there are two different units and unit costs appearing against this item, one entitled "Acre of Gross Acreage Involved," and the other, "Acre Credit." The former represents, as an example, the 40 acres contained within a one-sixteenth section upon which a reclassification survey was made, while the acre credit represents the acreage credited back as non-irrigable and reclassified as either high waste, grazing or meadow. To compute unit costs of this class of work on a basis of an acre of gross acreage involved, is to the writer's mind, the fairest way to handle it, the acre credit bearing less relation to the amount of effort or work involved than does the acre of gross acreage, considering that generally the entire forty must be investigated before results are obtained, whether these results show little or much credit.

The item designated as small structures relates to turnouts, checks, drops, wasteways, and small flumes and chutes. Standard plans were designed for these structures. They are, however, changed from time to time in an endeavor to improve their efficiency in operation. The engineering work consists of the compilation of data relative to the canal wherein the structure is to be placed, picking up station number, nearest B. M., setting grade hub and guard stakes, and designating location with 2x4 stake 3 in. long, painted with canal, station number, etc. After data is in office plan the material, duplicate engineering order, and memo is given maintenance department.

Farm laterals consist of investigation of original highland data and plats, examination of tract, determination of most practical arrangement of and number and proximity of ditches, proper gradients and provision for waste. This work is done for the farm upon his request, provided time can be spared from regular work. Farm lateral systems are surveyed on lands farmed by the company as a portion of the regular work.

Canal grades, for cleaning out or widening existing canals, consists of setting grade stakes or cut stakes in bottom and fill stakes on bank, obtaining exact station numbers, elevations and dimensions of all structures, painting station numbers on structures, setting B. M.'s on all turnouts, checks and drops. Duplicate engineering order containing the necessary information as to canal section, etc., is given the maintenance department.

New laterals consist of location, cross section, computation, inspection, final grades, drawing profile, plotting alignment and noting data on all records. The necessary structures on new laterals are placed under the heading of structures.

Fence lines consist of locating the necessary subdivision corners, and setting sights for line. This work is done for the farmer upon his request, provided time can be spared

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Wages of Workmen in Steel Mills.—Elbert H. Gary, chairman of the United States Steel Corporation board of directors, testifying Oct. 1 before the Senate Committee on Education and Labor, investigating the steel strike, set forth working hours in the corporation's steel mills and wage advances since 1914, in the following figures:

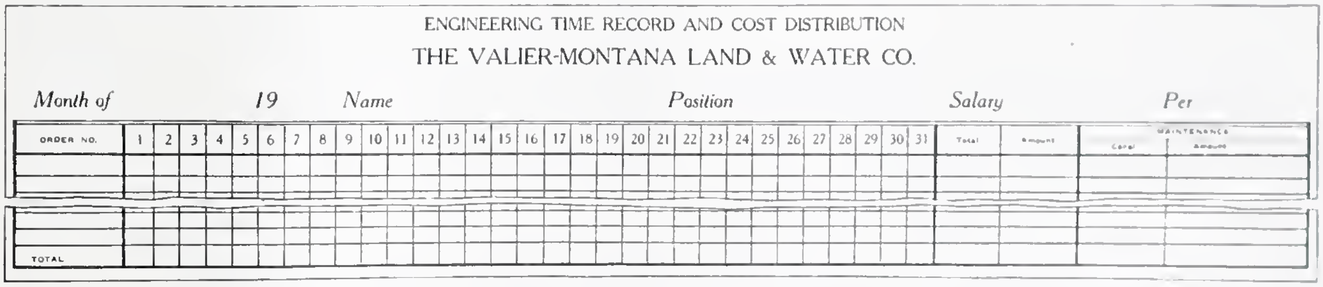
	Employes
Twelve hours	69,284
Ten hours	129,896
Eight hours	88,904

MANUFACTURING WAGES.

	1914	1919
Average of all	$2.93	$6.27
Coal and coke works	2.74	5.24
Iron ore works	2.75	5.70
Transportation	2.71	5.02
Miscellaneous	2.26	4.48

AVERAGE WAGES PER DAY.
(Excluding administration and selling forces)

July 1, 1919	$6.27
July 1, 1918	5.33
July 1, 1917	4.10
July 1, 1916	3.29
July 1, 1915	2.92
July 1, 1914	2.88



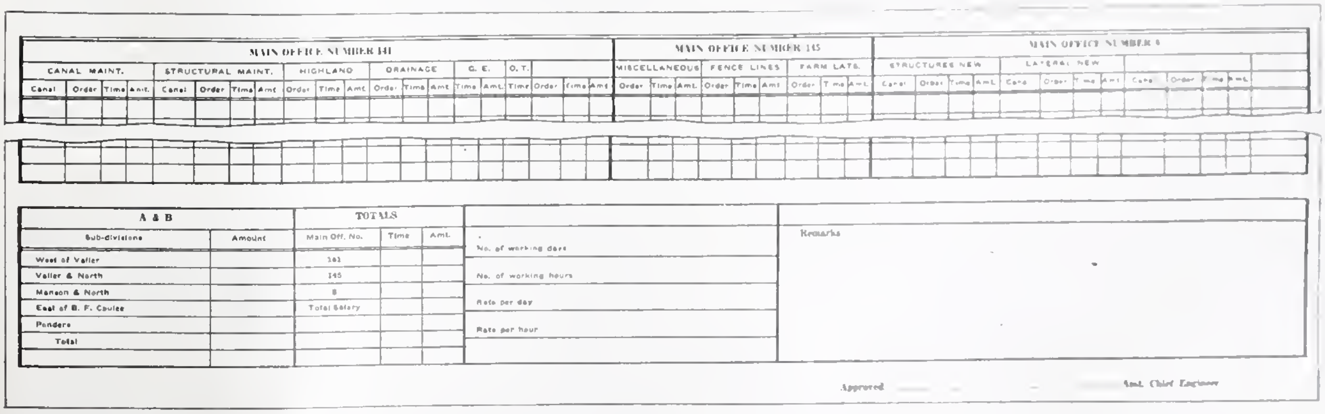
ENGINEERING TIME RECORD AND COST DISTRIBUTION

THE VALIER-MONTANA LAND & WATER CO.

Month of *19* *Name* *Position* *Salary* *Per*

ORDER NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total	Amount	MAINTENANCE Canal	MAINTENANCE Amount
TOTAL																																			

Left Hand Page.



MAIN OFFICE NUMBER 141																					MAIN OFFICE NUMBER 145									MAIN OFFICE NUMBER 8											
CANAL MAINT.				STRUCTURAL MAINT.				HIGHLAND			DRAINAGE			G. E.		O. T.					MISCELLANEOUS			FENCE LINES			FARM LATS.			STRUCTURES NEW				LATERAL NEW							
Canal	Order	Time	Amt.	Canal	Order	Time	Amt.	Order	Time	Amt.	Order	Time	Amt.	Time	Amt.	Time	Order	Time	Amt.		Order	Time	Amt.	Order	Time	Amt.	Order	Time	Amt.	Canal	Order	Time	Amt.	Canal	Order	Time	Amt.	Canal	Order	Time	Amt.

A & B		TOTALS				Remarks
Sub-divisions	Amount	Main Off. No.	Time	Amt.	No. of working days	
West of Valier		141				
Valier & North		145			No. of working hours	
Manson & North		8				
East of B. F. Coulee		Total Salary			Rate per day	
Pondera						
Total					Rate per hour	

Approved Asst. Chief Engineer

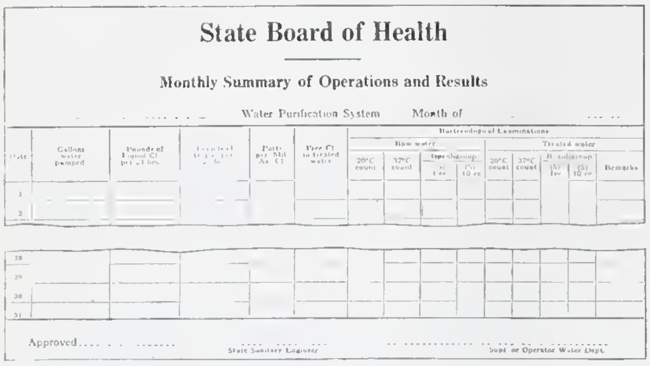
Right Hand Page.

Monthly Distribution Sheet for Engineering Time Record and Cost Distribution: Actual Size of Sheet 9½x16 In.

The monthly distribution sheet contains main office numbers, under which appear various classes of engineering work. The reason for this is that the main office books show a general distribution, while for the purpose of unit costs, the engineering department classifies the work in detail.

Form for Reporting Operations and Results of Water Purification Systems

The present plan of the State Board of Health of Wisconsin contemplates active general supervision over all water purification systems in the state. The report form illustrated below has been prepared for the purpose of keeping the board informed as to what each system is accomplishing. The daily results of treatment are tabulated by the operators and at the end of each month the form is returned to the board and filed.



State Board of Health

Monthly Summary of Operations and Results

.... Water Purification System Month of ....

Date	Gallons water pumped	Pounds of liquid Cl per 24 hrs.	[illegible]	Parts per Mil. Av. Cl	Free Cl in treated water	Bacteriological Examinations								Remarks
						Raw water				Treated water				
						20°C count	37°C count	B. coli group		20°C count	37°C count	B. coli group		
								(5) 1 cc	(5) 10 cc			(5) 1 cc	(5) 10 cc	
1														
2														
28														
29														
30														
31														

Approved........ .... State Sanitary Engineer .... Supt. or Operator Water Dept.

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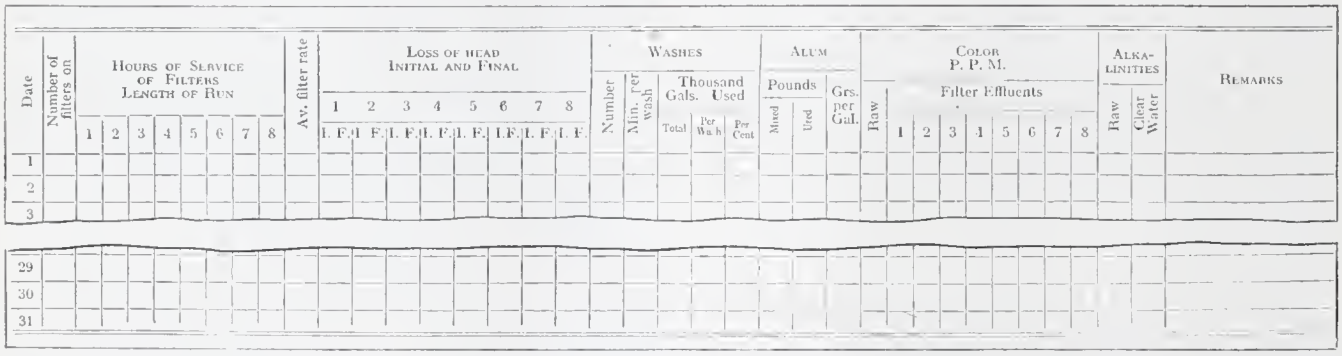

Date	Number of filters on	Hours of Service of Filters Length of Run								Av. filter rate	Loss of Head Initial and Final								Washes					Alum			Color P. P. M.									Alkalinities		Remarks
											1	2	3	4	5	6	7	8	Number	Min. per wash	Thousand Gals. Used			Pounds		Grs. per Gal.	Raw	Filter Effluents								Raw	Clear Water	
		1	2	3	4	5	6	7	8		I. F.	I. F.	I. F.	I. F.	I. F.	I. F.	I. F.	I. F.			Total	Per Wash	Per Cent	Mixed	Used			1	2	3	4	5	6	7	8			
1																																						
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Blank for Monthly Summary of Operations and Results of Wisconsin Water Filtration Systems. Actual Size 8½x11 In.

Training of Industrial Executives

The successful conduct of manufacturing enterprises demands that type of managerial talent which fully comprehends and effectively co-ordinates the social, commercial and technical forces which condition the life and prosperity of such institutions. The proper embodiment of physical, chemical and mechanical laws in industrial processes is the first essential in establishing a manufacturing enterprise upon a good technical foundation.

The provision of those conditions which release the creative faculties of the mind, which bring about the co-operative efforts of men and which establish understanding between labor and capital, are the golden fruits of management.

The distribution and marketing of the products of the factory, the financing of the enterprise and control of its activities in the light of market conditions are among the most serious problems dealt with in directing the affairs of an industrial undertaking. Accordingly, therefore, any training for service in manufacturing and industry which has for its object the development of men who shall occupy executive positions should be directed toward the great problems of labor and the human side of engineering, the problems of costs, accounting and finance, as well as the scientific and technical problems arising in industrial processes.

We are beginning to realize that the management of industrial enterprises is a matter of public interest and concern. The late war has demonstrated most forcefully the fact that our ability to combat is in direct proportion to our ability to produce goods; and between nations of equal resources the decision is generally in favor of the one which can produce, handle and use its goods most economically. As we enter the reconstruction period and begin to adjust ourselves to the new economic and social conditions which have arisen as a consequence of the war, we realize as never before that one of our greatest natural problems is the economic production and distribution of goods. And the greatest factor in this problem is that of man power of executive ability. We do not lack devices for production, systems of credit, methods of management—the tools to work with—but our need is men of vision, ability and force, well trained in commerce, finance and technology to direct our industrial organizations and cause them to function properly in all these particulars.

The development of men for such service is important to the public welfare. It is of more than passing interest, therefore, to note that the Engineering Schools of Columbia University have given serious consideration to this question and have developed a plan for training men for this service. Some years past Columbia, appreciating the growing importance of all engineering service to the public welfare and the increasing responsibility of the engineer to the public, raised its requirements for attainment of its engineering degrees to provide a more liberal education in the arts and the humanities. It provided that this new development shall also stand on the same broad educational foundation. An equivalent of three years' college training will therefore be required of all candidates for instruction in this branch of service. The instruction under the supervision of the engineering faculty extends over a period of three years, and is about equally divided between technical and commercial subjects. The School of Business of Columbia University is co-operating in the project and will give instruction in commercial practice and finance.

At a recent meeting of business men and educators held in Washington it developed that the Carnegie Institute of Technology and the University of Cincinnati were also working out similar projects and were offering instruction at the present time in those commercial subjects which are most important in matters dealing with the management of factories and the conduct of commercial enterprise.

With our universities and colleges developing men of broad vision and understanding in matters relating to the industrial and commercial development of our country, and with the introduction of these men into our business life, it is felt that the whole plane of commercial operation will be lifted and the problems perplexing labor and capital will be more thoroughly understood and more wisely handled.—Walter Rautenstrauch in the September Journal of the American Society of Mechanical Engineers.

One Result of the War.—The Knights of Columbus offered 100 scholarships in colleges and universities to service men. It is a significant fact that of the 2,300 applicants, 50 per cent requested courses in engineering, 15 in liberal arts, 10 in mining, 5 in agriculture, 10 in foreign service, commercial and consular, and 10 in medicine and law.

Convention of Iowa Section American Water Works Association.—The fifth annual convention of the Iowa Section of the American Water Works Association will be held at Mason City, Ia., Oct. 22 and 23. The headquarters will be the Chamber of Commerce. Jack J. Hinman, Jr., Iowa City, Ia., is secretary of the section.

POWER AND PUMPING SECTION

This section of the Waterworks and Hydraulic Monthly issue of Engineering and Contracting is devoted to the selection of power and pumping equipment and the economic management of its operation.

Reduction of Insulation Resistance in High Pressure Fire Service Motors, Due to Moisture

An investigation of the change in insulation resistance of the electric motors which drive the high pressure fire service pumps at the four stations in Manhattan and Brooklyn has shown some interesting and rather surprising results. In a paper presented last week at the 38th annual convention of the New England Waterworks Association Wm. W. Brush, deputy chief engineer, Bureau of Water Supply, Department of Water Supply, Gas and Electricity, City of New York, describes what has been observed and what has been planned to prevent in the future dangerous lowering of the insulation resistance. The following is an abstract of the paper:

High Pressure Fire Service Motors.—The more important commercial sections of New York City lying in the boroughs of Manhattan and Brooklyn are afforded exceptionally effective fire protection by the high pressure water supply system which is used only for the extinguishment of fires. In each borough there are two stations which have pumping equipment of similar design. In each Manhattan station there are six 6-stage centrifugal pumps having a capacity of 3,000 gal. per minute when delivering against a pressure of 300 lb. per square inch, while in Brooklyn the main station has five such pumps and the reserve station three pumps. The pumps are driven by 6,600 and 6,300 volt induction motors in Manhattan and Brooklyn, respectively. Ten of the Manhattan motors were installed in 1908 and two in 1911. All of the Brooklyn motors were installed in 1907.

One of the Manhattan stations is on South St., facing the East River, while the other is on Gansevoort St., adjoining the North River docks. The main Brooklyn station is on Joralemon St., near the East River, and the reserve station on St. Edwards St., about one mile from the river front. The proximity of three of the stations to the water increases the humidity of the air in their vicinity. The Manhattan and the reserve Brooklyn stations have the operating floor at the street level, while the main Brooklyn station floor is about 10 ft. below the street level. In all the stations the provisions for ventilation are normal. In the main Brooklyn station the basement is damp, and there is usually more moisture in evidence here than at the other stations.

Normal Operating and Maintenance of Motors.—In Manhattan a motor is started upon receipt of an alarm in the district covered by the station, and the necessary pressure maintained until notice is given by the fire department that no further supply is required. The number of times the service is required averages 550 per year for each station. In addition, every 24 hours each motor is started and run for about five minutes, when not otherwise put in service. This operation is mainly for the purpose of testing the condition of the motors and pumps, but also helps to dry out the motors. In Brooklyn, up to the introduction of the Catskill water, the proper station covering the district affected started a motor on each alarm, but during the past two years a motor is not started unless more than about 100 lb. pressure is called for. Under present operating conditions the two stations combined only operate on about 121 fires per year. The practice of running each motor once each day for about 5 minutes has also generally been followed in Brooklyn.

Failure of Insulation of Three Motors in the Main Brooklyn Station.—On Aug. 20th, 1917, there was a fire in Brooklyn, and after the station had been in operation for about 48 minutes one of the motors burned out. A second motor was started and ran for 42 minutes when it burned out, and a third motor was started and ran for 66 minutes, when it also burned out. A fourth motor finished the run on this fire, which required it to be in operation for about 45 minutes.

An examination showed that the insulation of the stators had failed, and that they would have to be rewound. This work was done at a total cost of $5,305, the greater part of the work being done at the station. The order to make the repairs was given in August, 1917, and the repairs were not completed until December, 1917. One of the three motors developed a short circuit in its rotor when it was being tested after repairs, and this damage required two months to effect the repairs, and cost $2,120.

It seems probable that the failure was due partly to the natural deterioration of the insulation from age, combined with severe conditions due to infrequent operation and high moisture. To minimize the danger of a repetition of failure from this cause, orders were given to run each motor for not longer than 30 minutes, and then change over to a fresh motor. Tests made at this time on the remaining machines at the Joralemon St. station showed insulation resistance from 1 to 1.8 megohms cold. Insulation resistances, measured warm, after 20 hours' baking by direct current of approximately full load amperage sent through the stator coils measured 0.7 to 1.8 megohms. These same machines showed 4 to 6 megohms cold.

This baking process was continued for about one week, at the end of which time the resistance cold measured from 8 to 10 megohms. The resistance warm, however, would drop to slightly under two megohms. It may be remarked that the weather conditions for the month of August, 1917, were relatively favorable, the humidity being considerably below and the sunshine considerably above normal. These machines were baked and varnished in January, 1918, after which the resistance measured some 300 megohms. In the summer of 1918, however, some eight months after the machines were baked and varnished, the insulation resistance dropped to slightly under two megohms on days when the weather conditions were unfavorable. In the spring of 1919 attention was called to the tendency for this insulation resistance to fall, and tests were made to overcome this by the application of external heat to the windings.

Inquiry of the manufacturers showed that they considered a minimum of five megohms resistance as necessary for safety of operation, although operating men of experience gave their opinion that two megohms would be sufficient.

During the nine days of rain in July tests were made in Manhattan and Brooklyn, which showed a resistance as low as 0.4 megohm on some meters. It is evident that the motors absorbed moisture from the air in sufficient volume to lower the insulation resistance to a dangerous degree, and that the operation of a motor still further increases this reduction in resistance and endangers the continuance in service of a motor in case it is required for fire use. Such a condition manifestly could not be permitted to continue, and it therefore became necessary to promptly determine the steps to be taken to secure an effective remedy.

Measures Taken to Prevent Reduction in Insulation Resistance.—It is evident that it is necessary to expel the moisture present in the insulation, and then either maintain a dry air around the motors or else to expel moisture from the motors at such intervals as might be found necessary to maintain a safe resistance. As far as could be determined, during the period when the stations were artificially heated, the resistance was reasonably high, but there is not sufficient evidence to be conclusive on this point.

It was decided to try various devices, such as covering each motor with a canvas housing, which could readily be removed by one man in case the motor was needed for service, and apply heat, using a small steam coil at the base of the motor frame. The canvas cover is to be made so that circulation of air through openings can be secured if desired, and it is believed that the canvas hood and steam coil will prove effective. Whether heat will be applied continuously or intermittently will be determined by experiment. A megger outfit has been requisitioned for use mainly in testing these motors, and in the future regular as well as special tests will be conducted.

Consideration was given to the use of unheated air, dried by means of a special electric fan or blower, and this method offers interesting possibilities which may later be tried out by tests, but for the present the drying of the air by heating seems to be the surest in its results.

Pumping Plants for Small Water Works*

By HENRY A. SYMONDS.

In designing a plant for pumping water for a small community, it is usually the case that the per capita cost of operating and maintenance is greater than in the large city plants, and it is important that a careful study be made of the relative merits of the different forms of power available, their adaptability, their cost, and efficiency when operating to do the particular work desired. It is usually the case that strict economy must be practiced in the introduction of these works, and studies relative to first cost have usually been made to bring the cost of the work within the ability of the communities to pay. Not so much attention, however, has been paid to the question of relative efficiency and daily cost of operation, and it frequently occurs that plants are in operation which citizens of the town, and even the water works officials themselves, believe to be highly economical, and that are the reverse. The difference in cost of operation may be so great as to make it good business to pay a much higher price for an economical unit.

The centrifugal pump has been known for a great many years, but for a long time after it was invented the difficulty of getting suitable drive with sufficiently high speed retarded the development of successful operation of this type of pump. The real growth of this pump has occurred in the past 10 years, during which time the use of the steam turbine and the electric motor with direct connection to the centrifugal pump has brought up the efficiency of the pump to a relatively high stage. At the present time the use of the steam turbine as applied to pumping water is mainly in the large units, and the motor is generally adopted for driving the smaller plants.

The result of the use of steam is, on the whole, satisfactory, but for the small water plants it is subject to the objections that the economical pumping machines with boilers are expensive and occupy much space, and provision for large storage of coal and adequate pumping station buildings are required, all of which conditions add to the first cost of the plant and are aggravated by the fact that licensed engineers are required to operate such a station.

Today we consider the ideal small pumping engine that which is economical in first cost, and is self-contained; i. e., operates from a source of power which is part of the engine or at least located in the same station. It is desirable to have it occupy as small space as is practicable, be simple in operation and not require the services of licensed men, easily repaired, quickly started, using fuel which is readily available at all times, and be capable of producing power at a relatively low unit cost.

Many of the conditions of an ideal plant are met by the electric motor, and the electrical installation has become more and more common. The advantages are: Low first cost; requires little space; low cost of maintenance; no expert supervision; it is especially well adapted to drive centrifugal pumps with direct connection, which saves friction loss of gears, and prevents noise; it may have automatic control; it may operate during periods of low load at central station, thereby getting lower rates; instant starting; as it has no reciprocating parts, it can be left to operate without attendance better than any other form of drive. The use of electricity has two serious defects in the average municipal plant; namely, it is not self-contained, but depends upon a line of wires and a power plant, usually at a distance, for its operation. For this reason neither one nor two units in a pumping station operated from the same plant are satisfactory to the insurance authorities, as they rightly claim that an accident to the wire line or the power plant will put both units out of use as quickly as one and leave the town or city in an unprotected condition in case of fire.

The advocates of the use of motors base their claims of low cost of operation upon the fact that attendance may be a minimum and that this is really the large item in operating small water plants. The writer believes that this argument has considerable merit, and that the improvement in efficiency brought about recently in the centrifugal pumps, and the low cost of the pump and motor, with the advantage above referred to, make this form of pumping plant a very close competitor of, and in some cases it will be found actually to be a better business proposition than the other types of pumps and engines in spite of the difference in efficiency.

Another form of drive which has been used in some of the small pumping plants is the gasoline engine. This form of power has practically all the advantages above mentioned except cost of operation, and in this it falls down badly, as it is operated upon a fuel of such high cost as to make the operation per horsepower-hour too high for practical purposes in the ordinary municipal water works. However, in plants where an emergency unit is wanted and electricity is not available or desirable for any reason, the gasoline engine may meet the requirements in a satisfactory manner.

The gas producer as a source of power corresponds to the boiler in a steam plant. It has a great many advantages, and when combined with a proper engine for utilizing the gas to the best advantage may be considered as having most of the requirements of the ideal plant. This form of power has been used for some time, and, so far as the writer has record, with good satisfaction in all cases. Gas produced in this way may be used in various types of internal-combustion engines with slight modification. A plant of this kind can be installed at reasonable first cost, is self-contained in so far as the power is generated directly next to the engine itself, and operates at a remarkably low cost upon a relatively inexpensive form of coal. The plant takes up more room than some of the other types, and calls for a larger pumping station space.

In the writer's experience, in nine cases out of ten fuel-oil engines have proved an ideal installation for plants from 25 to 150 hp., and for this reason it may be proper to give some extra details regarding this engine. The term "fuel-oil" is here used to mean any oil, from the heavier crude petroleum up to kerosene. Fuel-oil engines are today known under two general heads as Diesel and Semi-Diesel, or surface ignition.

The idea conceived by Diesel is the bringing into compression a mixture of air and oil vapor to a point where heat is generated sufficient to ignite the combination. The compression reached varies from 500 to 1,100 lb. per square

TABLE I—COMPARATIVE COSTS FOR DIFFERENT TYPES OF PUMPING PLANTS FOR SMALL WATER WORKS.

1,500 g.p.m., 250-ft. total head; operating 300 days per year, 9 hours per day; theoretical h.p., 94.7.

Pump.	Drive.	Pump efficiency per cent.	H.p. required.	Cost of fuel per h.p. hour.	Total fuel cost per hour.	Total fuel cost per 300 days.	Estimated cost of plant.	Remarks.
Vert. triplex	Fuel-oil engine	85	112	$0.004	$0.498	$1,209.60	$17,189	Guarantee—1 h.p. for 0.55 lb. fuel oil per hour. Price fuel oil, 4 ct. per gal.
Centrifugal	Fuel-oil engine	71	134	0.004	0.536	1,547.20	16,343	
Vert. triplex	Steam turbine	85	112	0.0075	0.840	2,268.00	13,657	Coal at $6 per ton (2,000 lb.)
Centrifugal	Steam turbine	71	134	0.0075	1 005	2,713.50	9,957	
Vert. triplex	Electric motor	76	125	0.0124	1.55	4,185.00	11,116	Efficiency is combined pump and motor. Electricity cost, 0.9 ct. per h.p.-hr. plus "service charge" of 77 ct. per h.p., based upon max. h.p. in use, per month.
Centrifugal	Electric motor	64	148	0.0124	1.84	4,968.00	6,248	
Cross - compound, fly - wheel, steam pumping engine						1,350.00	17,000	
Compound-duplex-Deane steam pump (original plant). Rate about 700 g.p.m.						2,725.61		Actual figures of present cost. Rates of pumping about 700 g.p.m.

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*From the Journal of the New England Water Works Association.

inch, but when the proper temperature occurs the gases burn rather than explode, and it is the claim of the producers of the Diesel type that this slower burning conserves the power of the gases, and the energy realized is utilized almost entirely in pushing the piston through the length of its stroke. In order to permit of the great pressure produced by this process, the machine must be exceedingly heavy, and the great amount of work which is required to perfect the Diesel engine makes it too expensive for the ordinary requirements of small water supply plants.

The Semi-Diesel, or surface-ignition engine, on the other hand, gets its power by the explosion of a mixture of air and oil gas in the cylinder under compression around 200 to 300 lb. per square inch. While part of the energy is undoubtedly used in the shock against the metal of the plunger and cylinder, the resulting thrust produces motion of the piston, which is connected through the crosshead, or directly to a crank shaft which gives the motion to the driving pulley or gear. The Semi-Diesel seems to meet all the ordinary requirements of the ideal engine described above, and while the first cost of this engine is considerably greater than that of the gasoline engine or the electric motor, the operating costs are so low that this outweighs in most cases the advantages of the low cost of the other machines.

In the types which are considered as small pumping outfits, designed to pump the water for communities of from 1,000 to 10,000 inhabitants, the engines required ranged from 25 to 150 hp., but in the writer's opinion there is a large field for a still larger oil engine, and there are some machines now being produced that show wonderful efficiency in operation. They are of the Semi-Diesel type, but are able to operate on the poorest grade of fuel oil, and even tar products which have to be heated before it is possible to get them into the cylinders. The oil used runs as low as 18°, while in the smaller machines—that is, below 60 hp.—the writer knows of good results with oil heavier than 26°, and with 25 to 35 hp. engines kerosene or light oils of that grade have seemed to give the most satisfactory results. Pre-war prices ranged from 2 cents to 7 cents for the various grades.

The ordinary time of starting with fuel oil is from 12 to 18 minutes, but engines of this type may be equipped with apparatus which permits of instant starting by electric ignition and gasoline, the fuel oil being turned on after a few minutes, without interruption of the operation of the engine. This latter contrivance is of especial value where but little storage of water is possible and pumps have to be operated in case of fire, as the delay in heating the cylinder head may be serious if the supply of water is not available.

It is claimed by the advocates of the electric motor, in comparison, that the motor requires little attendance, while the oil engine calls for constant supervision. This claim is not entirely substantiated in practice, for many of the oil plants are operating for long periods of time without attendance. This, of course, assumes that there are duplicate units which will take care of any fire hazard if repairs are necessary. It should also be considered that constant attendance does not eliminate many of the breakdowns.

Perhaps the most satisfactory combination that can be installed for a small pumping plant for general municipal needs is made up of two duplicate units, of which it is probable that the fuel-oil engine meets the needs fully as well as any other drive which has been developed up to this time.

One advantage, of considerable importance in some cases, that steam machines have over most of the other types is in the varying of speed in operation. The speed in the electric motor and of the internal-combustion engines is variable only to a small extent, except by change gears or belt pulley, and it is sometimes necessary to pump to waste or through a bypass back into the suction, an uneconomical process, in order to keep the rate of delivery as desired.

The writer had occasion, a short time ago, to make a comparison of different types of pumping plants, to determine which plant would best meet the needs of a community. In connection with this, the results of investigation of different units are given in Table I. These figures are not to be considered as exact, either of operation or first cost, but are obtained by using quotations and guaranteed efficiencies by the manfacturers of the different lines of machinery. These figures were also taken before the extreme rise of prices which occurred since the United States entered the war, and, while they are far above the averages of 5 years ago, it is probable that they are nearer what we may expect in the next few years than pre-war prices.

Suggested Improvements for Waterworks of Fort Wayne, Ind.*

City in General.—Population estimated to be 82,000; the United States census of 1910 showed 63,933. The city is located at the junction of the St. Mary's and St. Joseph rivers, which form the Maumee, and is an important manufacturing and railroad center. The city covers an area of 11.4 square miles, additions having been made in 1914; about 90 per cent is built upon. The surface of the city is undulating; elevations in feet above mean sea level range from 753 to 803;; in the congested value district, elevations range from 763 to 775. Grades are slight, the maximum for the city being a short stretch of 4 per cent. There are 212 miles of streets, 111.2 miles of which are paved; 57 per cent with asphalt, 29 per cent brick and 14 per cent miscellaneous. In and around the congested value district streets are paved and in fair to good condition; elsewhere their condition ranges from poor to good. Unpaved streets are in poor condition. Street widths in the congested value district range from 60 to 66 ft., averaging 65 ft. In the residential districts, street widths average 60 ft.

Conclusions Regarding Mains, Valves and Hydrants.—The system of main arteries and secondary feeders is incomplete. The lack of large mains in several manufactoring districts is particularly serious, resulting in excessive friction losses at times of high consumption and preventing adequate qualities for fire protection being delivered. Minor distributers are very largely 6 in. in diameter, poorly gridironed. The department has shown poor judgment in continuing to lay 4-in. pipe. Pipes have a moderate amount of incrustation.

Valve spacing is wide in all parts of the city, necessitating the cutting out of excessive lengths in making repairs. Non-uniformity in the direction of opening is a bad feature. The condition of valves and boxes is poor, showing the need of regular and systematic inspection.

Hydrant spacing is wide in all parts of the city, requiring the use of excessively long lines of hose at large fires. Hydrants are of good size, are in good condition, but very few have valves in connection to main.

Summary Water Supply Conditions.—Municipal works. Unsatisfactory features in organization. Records incomplete. Emergency operations fair. Direct pumpage from wells at four stations; distribution in one service with equalizing reservoir. Well supply seriously inadequate. Pumping capacity allows no reserve. Boiler capacity adequate. Stations have some wood in construction; hazards well guarded; no exposures. Consumption moderately low. Pressures low. Arterial system fair; excessive proportion of small pipe; gridiron fair to poor. Valves not inspected; in poor condition; spacing wide. Hydrants of good size; in good condition; few connections gated; spacing wide.

Recommendations Regarding Water Supply.—Organization: That all officials and employes of the water department be placed under suitable civil service rules requiring proper qualifications with removal from office only for cause.

Records: That complete detail drawings be made of the piping and other important features of the well fields, pumping stations and reservoir.

Supply Works: That a reliable supply be developed by one of the following plans. (A) By increasing the well supply. * * * (B) By developing a supply from the St. Joseph River. * * *

Mains: That the distribution system be strengthened by the installation of the additional mains to furnish fire supply as follows:

a. In residential districts, 1,500 to 2,500 gal. a minute.

b. In minor mercantile and manufacturing districts, 3,000 to 5,000 gal. a minute.

c. In the congested value district, 8,500 gal. a minute.

The above quantities to be in excess of maximum domestic consumption and to be available in high value districts about any large building or group of buildings of special hazard, and in other districts about any block.

That the following be adopted as the standard minimum sizes of mains used for hydrant supply for all future construction:

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*Abstract of report of National Board of Fire Underwriters' Committee on Fire Prevention and Engineering Standards.

a. In residential districts, 8-in.; 66-in. to be used only where it completes a good gridiron and in no case in blocks 600 ft. or more in length.

b. For mercantile and manufacturing districts, 8-in. and 12-in.; the former to be used where it completes a good gridiron and the latter for long lines not cross-connected.

That all 4-in. mains supplying hydrants be replaced according to the foregoing recommendation. Larger mains should be substituted immediately in important mercantile and manufacturing districts and in other localities in accordance with a well-defined plan by which all 4-in. pipe will be replaced within a reasonable period.

That dead ends be eliminated wherever practicable and mains be connected at all intersections.

NOTE.—The National Board believes that it is essentially the business of each municipality to lay out its system of distributing mains, as it is best able to judge of present and future consumption in each district and of other local conditions involving paving, topography, pressures, size and type of hydrants, etc., but practical experience has shown that the above sizes are required for good fire protection in districts such as are found in this city, and that a gridiron system of mains of the sizes recommended above, is satisfactory only when cross-connected at all intersections, free from dead ends, and with large secondary cross-feeder mains at frequent intervals.

Gate Valves: That the distribution system be equipped with a sufficient number of gate valves, so located that no case of accident, breakage or repair to the pipe system in important districts will necessitate shutting from service a length of main greater than the side of a single block, or a maximum of 500 ft., or in other districts greater than two sides of a single block or a maximum of 800 ft.

That the stems and nuts of all valves opening to the left be changed to conform in direction of opening to the majority of those in service.

That all valves be inspected yearly and large valves more frequently and that records be kept of inspections, operation and condition.

Hydrants.—That additional hydrants be installed so that there will be:

a. In the congested value district, two hydrants at each street intersection, and intermediate hydrants on two sides of each block.

b. In important minor mercantile and manufacturing districts, two hydrants at each street intersection with intermediate hydrants in long blocks.

c. In other districts, one hydrant at each street intersection with intermediate hydrants in long blocks, the distance between hydrants in no instance to exceed 350 ft.

That all hydrants installed in the future and those at present connected to large mains, particularly in important manufacturing and mercantile districts, be provided with gated connection to main.

That the misuse of hydrants be reduced by confining their use to the fire and water departments, and that cranes be provided for filling street sprinkling and flushing wagons.

Personals

M. D. Hadley has been appointed city engineer of Ellensburg, Wash.

Richard H. Brinkley, city engineer of Suffolk, Va., has been appointed city manager.

Fred E. Buck, assistant city engineer of Butte, Mont., has been appointed state irrigation engineer of Montana.

George J. Calder has heen appointed construction engineer for the Sacramento River filtration plant of the City of Sacramento, Calif.

G. N. Pfeiffer, of Herrin, Ill., and Arthur C. Mallams, of Pittsburg, Kan., have entered into a partnership under the firm name of Pfeiffer & Mallams and will engage in a consulting engineering business with offices at Herrin.

Leonard Peterson, for the past nineteen years superintendent of the water and light department of Thief River Falls, Minn., has resigned to become local manager of the Crookston Water Works Power & Light Co., Crookston, Minn.

Walter E. Rosengarten has resigned his position as highway engineer in the U. S. Bureau of Public Roads to accept the position of traffic engineer with the Asphalt Asociation, with headquarters at 15 Maiden Lane, New York City.

J. K. Anderson, who has been the chief engineer of the West Virginia Public Service Commission for the last six years, or ever since the commission was first organized, has tendered his resignation to the commission and will go into private engineering business. Mr. Anderson will be succeeded by George E. Taylor as chief engineer, and Mr. Taylor's position as assistant engineer, which he has held for four or five years, will be filled by W. Q. Galligher of Charleston, W. Va., who formerly was an engineer with the Virginian Power Co.

Lieut.-Col. E. V. R. Payne, the first resident barge canal engineer stationed at Lyons, N. Y., who is now assistant engineer in the department of the state engineer and surveyor at Albany, has received his final citation and decoration as a chevalier of the Legion of Honor of France.

Capt. Robert B. Murdock, who has recently returned from military service in France, has been appointed executive engineer with the Asphalt Association at 15 Maiden Lane, New York City. He will directly assist the secretary of the association in developing the organization and operating policy.

Paul L. Bean has resigned as chief engineer of the Public Utilities Commission of Maine and will enter into a partnership with Walter H. Sawyer, under the firm name of Sawyer & Bean. The firm will engage in general engineering, specializing in hydraulic engineering and rate cases. Offices are at Lewiston, Me.

William M. Black has been appointed chief engineer of the State Public Utilities Commission of Maine He graduated from the University of Maine in 1909, after which he had two years with the American Bridge Co., a year in subway construction, and the balance of the time in general engineering in New York City.

Capt. Charles H. Lee of Berkeley, Calif., has been appointed executive member of the State Water Commission of California Capt. Lee was connected with the U. S. Geological Survey in 1905 and 1906, and from 1906 to 1912 was a member of the engineering force that built the Los Angeles aqueduct. From 1912 to 1917 he engaged in private practice, devoting himself to irrigation work.

C. M. Baker of Nashville, Tenn., has been appointed chief sanitary engineer of the department of sanitary engineering of the Wisconsin State Board of Health. Mr. Baker took his civil engineering degree at Cornell University in 1908 and master's degree in 1907. He has been instructor in engineering at Cornell, assistant sanitary engineer with the New York State Department of Health four years, and with the United States Public Health Service one year.

Maj. C. E. Smith, recently with the construction division of the army, has resumed the management of C. E. Smith & Co., consulting engineers, St. Louis, Mo. The company has opened a Chicago office at 1313 Steger Bldg., in charge of W. C. Curd, who was engaged for many years in general railway work, also as drainage and water service engineer for the Missouri Pacific system, and with Layne & Bowler Co., and Wm. Graver Tank Works on water supply and purification. He will give special attention to water supply, river protection and drainage. W. D. Hudson, formerly assistant bridge engineer, Missouri Pacific system, and G. H. Packwood, Jr., formerly electrical engineer, City of St. Louis, have become associated with the company.

Industrial Notes

Charles C. Baird, former western manager of sales, National Fireproofing Co., has associated himself with The Camp Brothers Co., Akron, O., to engage in the manufacture of hollow building tile and other clay products.

The Bucyrus Co., South Milwaukee, Wis., has moved its southern sales office from New Orleans to Birmingham, Ala., where it will be located at Room 2212, Jefferson County Bank Bldg. C. N. Ballentine remains as southern sales manager and will be assisted by E. J. Wilkie, who for many years has been connected with the sales department at South Milwaukee.

The Van Wie Pump Co., Syracuse, N. Y., successors to the Baldwinsville Centrifugal Pump Works, established in 1860, has retired and sold its business—drawings, patterns, good will, etc.—to the East Iron & Machine Co., Lima, O. The line manufactured by the Van Wie Co. includes vertical and horizontal centrifugal pumps, double suction pumps, sand pumps, hydraulic dredge pumps, single acting triplex pumps and vertical steam engines. The East Iron & Machine Co. at its plant in Lima will manufacture the entire line as well as make parts and repairs for all Van Wie products. It is also their intention to make improvements in several of the pumps.

Statement of the Ownership, Management, Circulation, Etc., Required by the Act of Congress of August 24, 1912,

of Engineering and Contracting, published every Wednesday at Chicago, Ill., for October 1, 1919.

State of Illinois, County of Cook, ss.—Before me, a notary public in and for the state and county aforesaid, personally appeared H. P. Gillette, who, having been duly sworn according to law, deposes and says that he is the Editor of Engineering and Contracting and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc. of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor and business manager are:

Publisher—Engineering and Contracting Publishing Co., Chicago, Ill.

Editor—H. P. Gillette, Chicago, Ill.

Managing Editor—C. T. Murray, Chicago, Ill.

Business Manager—L. S. Louer, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)—H. P. Gillette, Chicago, Ill.; L. S. Louer, Chicago, Ill.; N. M. Rodgers, Chicago, Ill.

3. That the known bondholders, mortgagees and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities are: (If there are none, so state.)—None.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association or corporation has any interest, direct or indirect, in the said stock, bonds or other securities than as so stated by him.

(Signed) H. P. GILLETTE, Editor.

Sworn to and subscribed before me this 29th day of September, 1919.

C. E. Meinders.

(Seal.) (My commission expires June 7, 1920.)

Railways and Excavation Monthly Issue

ENGINEERING AND CONTRACTING

Published by Engineering & Contracting Publishing Co., 608 South Dearborn St., Chicago.
HALBERT P. GILLETTE, *President and Editor* LEWIS S. LOUER, *Vice-President and General Manager*
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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field if subscribed for as a weekly at $3.00 a year; but any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year (or any two monthly issues at $1.50 a year) and the 4 special quarterly issues will be sent without extra charge. Three of these special quarterly issues relate entirely to foreign engineering and construction practice, and the fourth is our annual "New Equipment Issue." The *articles* in the first two issues of each month (1st and 2nd Wednesdays) completely cover the municipal engineering and contracting field. The *articles* in the first and last issues of each month (1st and 4th Wednesdays) completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and last issues of each month (3rd and 4th Wednesdays) completely cover steam and electric railway location, design and construction. See the "mast head" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging (c) Quarries and Pits
(b) Rivers and Canals (d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings (c) Harbor Structures
(b) Bridges (d) Miscellaneous Structures
(e) Properties of Materials

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The Cummins Bill for the Control of the Railways, and Its Cardinal Weakness

The Senate Committee on Interstate Commerce, of which Senator Cummins is chairman, is about to present to the Senate the draft of a bill to regulate railways doing an interstate business. It is likely that in a modified form this bill will become a law within the next six months, possibly sooner. The six salient features of the bill are:

1. The return of the railroads to private ownership, but with the understanding that their operation is to be strictly supervised by a federal board of transportation, created for that purpose.
2. Division of the country into several districts and the grouping of the railroads for purposes of rate making.
3. Consolidation of the railway lines into not less than 20 nor more than 35 distinct competing systems.
4. Settlement of disputes between the employes and the companies by means of a committee on wages and working conditions, consisting of eight members, of whom four would represent labor and four the railroad companies.
5. Prohibition of railroad strikes or lockouts, with drastic penalties for any attempt to obstruct interstate commerce by such means.
6. Division of profits in excess of a fair return on the value of the property into two equal shares, one to be used in bettering working conditions, and the other in improving service.

The last two of these six features are the most radical in the eyes of most people. The American Federation of Labor, through its president, Samuel Gompers, has declared that the strike weapon must not be taken from the hands of labor. Several great railway presidents have declared that to deprive every railway system of all profits in excess of, say, 6 per cent on the "value" of the system would remove nearly all incentive to economize in operation. Charles Evans Hughes goes so far as to say that it would be unconstitutional to allow "profits" in excess of a fair retrun.

The daily papers, especially since the great railway strike in England, have been almost unanimous in approval of the provision of the Cummins bill for "disarming the railway unions." Thus the Chicago Tribune says:

> Mr. Gompers recently has asserted that the Cummins railroad bill would enslave workers by denying them the fundamental right of striking. He fails to reflect, we think, that there is another right involved: the right of the sovereign people to maintain the integrity of industries absolutely essential to life itself.
>
> It is pretty well understood that certain services are inextricably bound up in the welfare of the nation. A soldier having the right to strike at will might choose the critical moment. Not even in bolshevist Russia would it be tolerated. A policeman, standing in the position of public guardian and with authority delegated directly by the people can have only one duty, and this to its sovereign, the people.
>
> We speak of these directly delegated services because self-defense is fundamental. We will thrust aside every con-

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

vention to maintain the principle. But if the presence of a material and physical enemy arouses us to such a pitch of defense, what of the no less deadly but unseen enemy of hunger?

The right of railroad men to strike implies the right to throttle transportation, an industry essential in a vital degree to our very lives; implies, in short, the right to suspend the nation's right to eat. Without railroads we can have neither food nor fuel. Will 120,000,000 people grant this autocratic privilege to a small percentage of the whole co-operative community?

Group rule inevitably must lead to a rule of sub-groups, and so on down to the individual; until, at last, suspending the whole fabric of fraternal protection and mutual help, the race must find itself where it came from—living in the trees and carrying knotted clubs.

The new era we are talking about must be an era of co-operation and responsibility and good will, not of group assertiveness and group jealousies, else the tree and the club.

We have already editorially expressed our approval of the plan to take the strike weapon from railway employes, and this we did twelve years ago, as well as in a recent issue. But it was also about twelve years ago that we pointed out the economic fallacy of limiting the net earnings of any railway to a fixed percentage on the invested capital. We showed that such a plan not only removes the greatest incentive to reduce ton-mile and passenger-mile operating expenses, but that it actually puts a premium upon excessive investment in plant. Under such a plan, Marconi, for example, would have had no incentive to develop the wireless telegraphy, for his chief object was to reduce telegraph plant investment to a minimum, and the attainment of his object would have resulted in no reward had the government prescribed a profit limit of, say, 6 per cent on the cost of the wireless plant.

Anyone can easily see that the limiting of profits to a fixed percentage on plant cost would discourage most inventors and practically all capitalists who finance inventors. But, due to a misconception as to the fundamental nature of inventions, relatively few people realize that nearly every bit of economic progress involves some originality, some inventiveness. Take, for example, the work of a civil engineer engaged in designing a bridge. It may involve no radical departure from precedent, but it invariably involves some departure, if it is not a mere copy of some existing bridge. Structural engineers know that no two engineers will design exactly the same bridge for a given river crossing, also that one of the two will be more economic than the other, also that, other qualifications being equal, the more inventive engineer will produce the more economic design. Precisely the same thing holds true of every sort of design, even to the design of a system or plan of managing men.

Inventors who secure a patent are given an opportunity to enjoy some—but not all—of the fruits of their ingenuity. For a term of 17 years they are protected against competition in the use of their specified invention. In similar manner it is feasible to reward originality exercised in the location, desgn and operation of a railway, for rates of charge for transportation can be fixedd for a specified term of years. But under the Cummins bill, as soon as net earnings are increased by sagacious management the owners of the railway face the certainty that they will enjoy none of the increase. It has been this very condition of affairs during the past 15 years that has driven so many capitalists away from the railway field.

Interstate commerce commissions and state railway commissions have repeatedly reduced railway rates because they yielded net earnings exceeding some fixed "fair return" percentage on invested capital. The result has been not merely to bring most railways to the verge of bankruptcy, but, what is worse, to bankrupt many of them as to directive brains among the principal owners—those in whom the authority to authorize changes finally rests. Elsewhere in this issue we quote a pertinent editorial on this subject, from a recent issue of the Philadelphia Public Ledger.

Why Should Smith Pay Part of Jones' Freight Bill?

During the first eight months of 1919 the railroad deficit in the net earnings guaranteed by the government has been 300 million dollars. Not many years ago it cost only a billion dollars a year to run our entire government. Now the government must raise nearly one-third of that amount in taxes merely to make good two-thirds of a year's deficit in railway operation, yet scarcely a protest is heard! Is it because people are becoming so accustomed to enormous taxes that they accept another 40 million a month as a matter not worth quibbling over?

Directly or indirectly every earner of an income pays taxes. Unfortunately most of us pay most of our taxes indirectly and do not therefore realize what a large sum we really pay. The landlord passes most of his taxes on to the tenant, in the form of higher rent. The merchant does the same sort of thing to his customers, in the form of higher prices. So the game of passing the tax "buck" goes merrily on, although few realize the extent to which the "buck" serves to reduce the amount of goods that they can buy.

It is estimated that the government will pay out ten billion dollars in 1919, or $90 for every man, woman and child, or about $350 for every family. About $25 of the $350 is going to make good the government's deficit in operating the railways. Well might each of us ask our congressmen why railway freight rates should not be raised so as to eliminate the deficit in net earnings, for why should not each shipper pay his own freight bills in full?

The Effect of Democracy, Political or Industrial, Upon Wages

Nearly all cities have been lagging behind private corporations in raising the wages of employes. A typical instance is Chicago. The annual salary of the average employe of this city is now $1,715, as compared with $1,194 in 1915, or an increase of 44 per cent. The U. S. Steel Corp. now pays its average employe (exclusive of the administrative and selling forces) $1,950 a year, as compared with $925 in 1915, or an increase of more than 110 per cent.

The following table shows the increase in salaries of the different classes of city employes in Chicago since 1915:

	1915.	1919.	Pct. inc.
Medical	$1,062	$1,427	34
Engineering	1,793	2,179	22
Clerical	1,232	1,660	29
Police	1,335	1,836	38
Operating engineers	1,652	1,878	49
Fire	1,473	1,991	35
Inspection	1,405	1,925	37
Supervising	1,315	1,527	16
Skilled labor	1,235	1,672	35
Common labor	704	1,265	76
Average	$1,142	$1,684	47
Exempt	2,077	2,416	16
General average	$1,194	$1,715	44

The "exempt" class includes the mayor and other elected and appointed officials exempt from civil service examinations. The "exempt" and the "supervising" classes stand at the bottom of the list in point of percentage increase, each having only 16 per cent. Next in order of rank as holders of the "dirty end of the stick" stand the technical engineering forces, with an increase of only 22 per cent. Is it any wonder that many of the technical engineering force have joined the draftsmen's union?

Many inferences may be drawn from such data as these, but perhaps the most important inferences are these two:

First, that where city or national governments are the employers of men there is a tendency to pay about the same salary to every class of employes. This explains, in part, the quite prevalent desire of labor unions to "nationalize industry."

Second, that those classes of men that command the most votes, either because of their numbers or because of their organized affiliation with other classes, secure the greatest increases in income. This explains, in part, the tendency of labor unions to affiliate, as in the American Federation of Labor.

Opposed to the "one big union idea," which is naturally espoused by workmen whose pay is relatively small, are the classes of union men whose income is relatively large. The Brotherhood of Locomotive Engineers, for example, is not particularly desirous of surrendering its independence by joining a labor democracy. Were it to do so, being outnumbered by workers receiving lower wages, this brotherhood would soon be compelled either to accept a lower wage for its members or to witness a rise in all lower wages to the level of the higher wages.

Those who incline to favor "industrial democracy" will do well to consider the ultimate outcome of a plan that would give each worker a vote not only as to what his own wage should be, but as to what the wages of other classes of men should be. "Industrial democracy" has an attractive ring in the ears of members of a political democracy, but this should not be allowed to lead to an emotional approval because of its sweet cadence. What is really back of this euphonious sound? What is the meaning of it? Does it merely signify a plan to give every worker a limited voice in the management of industry? Or does it give every worker as much of a voice as every other, including those who are directing the work? If the latter is the meaning, then there will be the most vigorous opposition to "industrial democracy."

In the conduct of any enterprise involving the cooperation of many men, it is fatal to give each of the men an equal vote on every question at issue. Not only does such a procedure result in endless wrangling, but it is tantamount to approval of the ridiculous proposition that any man is as well qualified to pass judgment on a given question as is any other man. We who are engineers know all too well that no technical problem can be solved so well by non-technical as by technical men; and we chafe whenever we are compelled to submit a technical question to laymen to pass upon. Yet, every economic problem is really a technical problem, that is, one that requires scientific study for its correct solution. The management of men, for example, requires nothing less than the solution of a vast number of psychological and physical problems. Shall such facts be ignored, and shall every man have an equal voice in the management that controls his own actions as well as those of his fellows?

Let Russia, if she will, continue to work upon the theory that complete industrial democracy will yield a larger income for the average man than is attainable under the capitalistic system. Let the experiment be tried by any other country that chooses to do so, but let America continue to operate under the old plan, with such modifications as naturally evolve. When Russia or any other country demonstrates that complete industrial democracy yields a larger income and a greater meed of pleasure to the average worker, then we may safely pass from what we know to be fairly good to what is proven to be better.

Railway Commission Fixes Rate for Motor Truck Haulage

Standard rates for motor truck haulage have been established for eastern Nebraska by the State Railway Commission. In fixing these rates the following estimate of operating costs, based on the truck with a 4,000 lb. load, driven 50 miles daily, was used by the Commission:

	Per ton mile. Ct.
Operating:	
Gas (at 25 ct. per gal) and oil (at 75 ct. per qt.)	2.500
Chauffeur's wages ($24 weekly with $2 daily expense allowance)	7.200
Maintenance:	
Running repairs	2.500
Depreciation (on basis of 3,600 miles)	4.160
Repair of tires, etc. (life of 7,500 miles)	1.870
General:	
Salaries, rent, etc.	3.000
Insurance	.500
Loss and damage	.800
Taxes ($1,200 per ton for first year of truck's life, $800 per second year and $100 per third year)	.027
Return on investment (2 per cent)	2.500
Total	25.057

The rates cover a schedule within a radius of 60 miles. Four classifications are provided for in these rates between points not within the same city or village. The minimum charge for first class commodities is 15 ct. per 100 lb., in addition to which a charge of 1.5 ct. is made for each mile. Second class rates are 85 per cent of this figure, third class rates are 70 per cent and fourth class rates are 60 per cent. The minimum charge is 50 ct.

Trailer Bonus for Crushed Stone Deliveries.—A simple trailer bonus plan is operated by the Dunbar Stone Co., Detroit, Mich. Every time a driver take out a trailer he gets a brass check; he accumulates these until pay day, when he turns them in and gets a stipulated amount of money for each in addition to his regular wages. All the drivers hauling trailers get so much per hour extra all through the month, in addition to the bonus. They are considered in a class a little above the regular truck drivers, for they carry a helper while the others do not.

Power to Prevent Strikes

Editorial in the Public Ledger, Philadelphia.

Whichever one of the several suggested methods for the ultimate surrender of the railroads of the country to the management of their owners may be finally accepted by the Congress, the suggestion embodied in the Cummins plan for the elimination of strikes and lockouts ought by all means to be included. It is significant that this portion of the Cummins plan has already been attacked by the leaders of the railroad unions, which resent any suggestion of a limitation upon their right to use the strike as a weapon against their employers, whether they be the private owners of the roads or the government. They forget, however, the interests of the third party to the issue, the great American public, and its right to the uninterrupted service of this, the greatest and most vital of their public utilities. The subject is fraught with difficulties, but as a legal correspondent of the New York Tribune indicates, the Supreme Court of the United States has pointed out the difference between the right of employes engaged in private business to leave their employment and even by concert of action to agree with others to leave, and the position of employes engaged in a business charged with a public interest. And the same tribunal has in effect if not expressly decided that the Congress has the right to legislature to protect the public right in such a case as is presented by the present discussion. It is certainly an intolerable wrong that the people should have no protection against the irreparable injury that would be inflicted upon them if the railroad brotherhoods should carry out the threat with which they accompanied their last demand for a wage increase. And the Congress would be negligent of its most imperative duty were it to fail to heed the emergency and take means to safeguard the public rights, whether by some system of compulsory arbitration where public utilities are concerned or by penalizing the breaking of contracts by those engaged in the transportation of interstate commerce.

New Hydro-electric Plant in Manitoba.—One of the largest hydro-electric plants in North America is to be built at Little du Bonnet Falls, on the Winnipeg River, a short distance northeast of Winnipeg. It is proposed to expend $9,000,000 on the work and the expectation is that 160,000 h.p. will be developed. The first step in the project will be the building of a dam of concrete, 2,000 ft. long and of a maximum height of 70 ft. across the Winnipeg River at Little du Bonnet Falls. The dam will create a reservoir from 50 to 70 ft. in depth, extending several miles up the river to the second McArthur Falls, and, by raising the river's level will drown out Grand du Bonnet Falls where the river drops 35 ft. in four plunges. Eight turbines of 21,000 h.p. each, of four-runner, horizontal shaft type, will be installed in pits in the concrete substructure. The water from the reservoir will pass directly into the turbines at 20,000 cu. ft. per second. The power generated at the plant will be conveyed to Winnipeg by a double circuit transmission line supported across country on structural towers 54 ft. high. A second double-circuit line will connect the power house with the power plant at the Winnipeg Electric Railway at Pinawa higher up the river. A double-loop connection will thus be maintained between the city and the source of power.

Soil Stripping for Miami Conservancy District Dams.—Excavation for the soil stripping for the dams for the five retarding basins of the Miami Conservancy District of Dayton, O., has been done by means of elevating graders. The specifications required the removal of all vegetation, stumps, roots 1 in. or more in diameter or any unsuitable material. At the Englewood dam the grader was hauled a portion of the time by a large tractor and the remainder by 16 mules, 4 in lead, 6 on pole and 6 in rear. These were served by 14 three-up bottom dump wagons. The material was stored in windrows just outside the toes of the dam, to be later spread over the graded slopes as soil dressing. Work was done during the summer months. There were 56 possible working days and 47 actually worked, a loss of time of 16 per cent due to weather. The average loaded haul was from 150 to 200 ft. The material moved aggregated 45,000 cu. yd. and the depth of cut was about 7 in., or one plowing. The daily yardage moved averaged 945 cu. yd. working a 10-hour shift.

Method of Controlling Curvature of Diamond Drill Holes

One of the main limitations of the diamond drill has been its inability to drill a straight hole. To depths of 1,000 ft. the deflection often is not large, but all holes tend to curve and take somewhat erratic courses. Accurate survey methods have made it possible to interpret curved holes, but there are many cases where highly valuable information cannot be obtained if the curvature cannot be controlled. The Mond Nickel Co., which drills about 50,000 ft. per year, has adopted a standard practice of wedging for controlling the direction of drill holes that appears to overcome one of the large limitations of the diamond drill. Holes that warrant this expense are wedged both to vertical or both to a straight line as soon as they show deflection of over 3°. The method of the Mond Nickel Co. was described by O. Hall and V. P. Row, respectively mine superintendent and exploration engineer of the company, in a paper presented last month at the Chicago meeting of the American Institute of Mining and Metallurgical Engineers. An abstract of the paper follows:

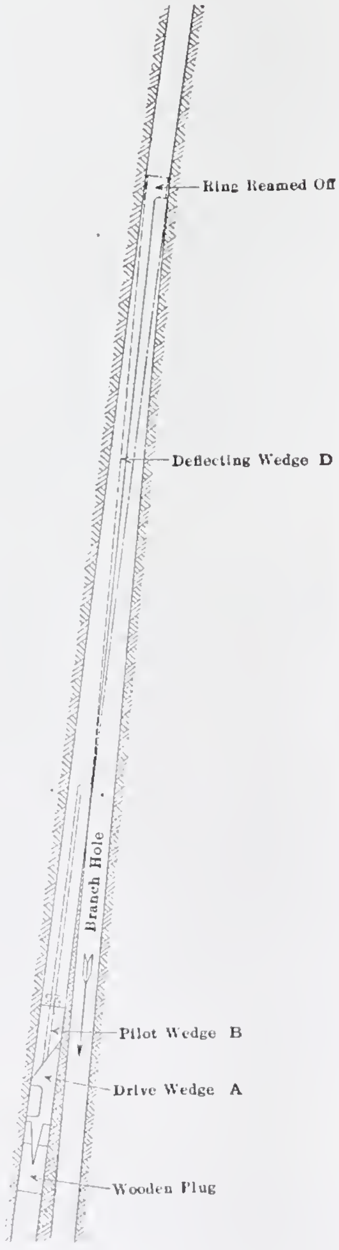


Fig. 1—Diagram of Diverting Wedges.

A diagram of diverting wedges is shown in Fig. 1. Each wedging requires the use of a wooden plug, a drive wedge A, a pilot wedge B, a deflecting wedge D, a special clinometer C, Fig. 2, and a special reaming bit E. Wedging is possible in any hole and no change of size is made, that is an "E" hole remains "E" size, an "A" hole "A" size, and a "B" hole "B" size. The dimensions and description given are for "A" holes.

To wedge a hole at any point, a dry, turned, wooden plug grooved to allow water to pass is pushed down with the rods to the point where it is desired to branch the hole and allowed to swell. A drive wedge is then dropped into the hole and driven into the wooden plug, using a blank bit for driving. The drive wedge, being cut out below the face, usually falls with the face of the wedge in the direction of dip but in every case its position is surveyed carefully by using the special clinometer C, Fig. 2. Lines are cut on the inside of the clinometer parallel to and in the plane of the long axis of the 30° beveled part of the clinometer. Lines indicating this plane are marked on the side of a glass test tube with a small carbon, the low point of the bevel face being indicated. The glass tube is filled to a height of about 2 in. with hydrofluoric acid diluted with two parts of water, a cork put in, gummed paper placed over cork and fastened to the sides of the tube, and the plane marked across the paper so that it fits the clinometer snugly and when lowered into the clinometer the marks coincide. The clinometer is lowered into the hole and allowed to set 30 minutes to take the etching; it is then pulled up, the tube cleaned and dried, and the low and high points of the etching marked when the tube is held vertical. The relative direction of the face of the drive wedge and the dip of the hole are indicated. If the two low points coincide, they are the same and it is only necessary to set the face of the pilot wedge and the face of the deflecting wedge in the same direction and lower them. If the two low marks do not coincide, it is necessary to determine the angle between them and to rotate the pilot wedge with regard to the deflecting wedge, to bring the deflecting wedge, when in place, in a direction opposite to the dip of the hole. Strips of paper wound around the test tube and wedges allow marking and measuring the arc determining the angle. If the dip is small, a standard dip protractor or the transit and protractor may be necessary to determine the low point of the etching.

A ring is left at the top of the deflecting wedge to lower it. The pilot wedge and deflecting wedge properly orientated are lowered by riveting a special lowering plug threaded into a blank "A" bit to the ring with a copper rivet. Neither the 30° face of the drive wedge nor the face of the pilot wedge is brought to a thin point but an end ¼ in. thick is left. This provides a surface for driving the drive wedge; also, in one position, the point of the pilot wedge will rest on the point of the drive wedge and on being rotated 180° the pilot wedge will drop 2 in. into its place, indicating when the two are in their proper relation. Shearing of the copper rivet gives a further drop of 3 in. The amount of stretch in the rods must also be taken into account in working at depth; 1,500 ft. of "A" rods have about 2.5 in. of slack.

When the deflecting wedge is in place, an "E" bit and core barrel are used and an "E" hole drilled to a point 3 or 4 ft. (0.9 or 1.2 m.) below the wedge. The curved face of the deflecting wedge is "E" size, so the "E" bit follows the wedge without cutting into it. After the "E" drilling, the wedge and deflected hole are reamed out with the special reaming bit "E." The small part of this is "E" size and acts as a pilot. Diamonds are set in the beveled part to ream the wedge and hole out to "A" size. After doing this, the regular "A" rods and "A" bit are used, but reaming with the "A" bit is started at the top of the wedge to make sure there is ample clearance for passing up and down. The "A" hole is continued as an "A" hole below the wedge.

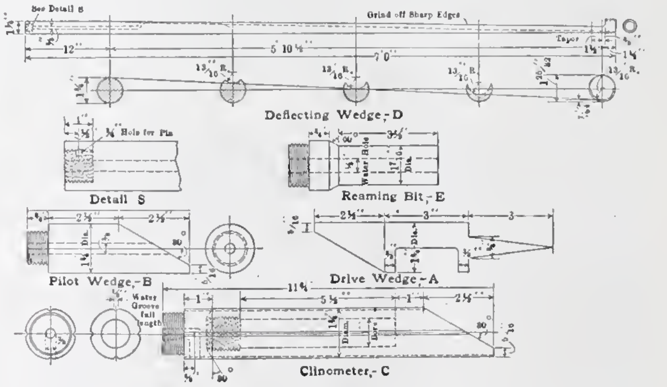


Fig. 2—Wedges and Clinometer for "A" Rods.

Wedging was first tried in a vertical hole that had been abandoned as useless at 1,100 ft. The hole was branched by a wedge at 436 ft. where the deflection was 5° and by using seventeen wedges, was guided to a depth of over 2,400 ft. with a deflection under 24°. The correction per wedge was less than expected and the work indicated that it would have paid to start a new hole and wedge whenever the deflection exceeded 3°. The upper part of the hole was a fissured granite or gneiss; the lower, fissured quartzite. The first wedgings were expensive and only partly satisfactory but a skillful setter and crew corrected the difficulties, making accurate wedgings without difficulty after the third wedging. The average correction per wedge was 2°. Two subsequent holes in norite, greenstone, and granite were drilled to depths of over 2,500 ft., keeping the deflection within 5° by using three wedges in each. One of these holes had deflected to 5° at a depth of 362 ft. It was wedged at 328, 472, and 580 ft., bringing it back to 1° 10′. The other was out 2° 25′ at a depth of 700 ft. A wedge brought this back to 0° 35′. Though new to the work the setters and crews on the latter holes had no difficulties. Thin core shells being lowered to recover lost cores should be lowered slowly past the top of a wedge. The first deflecting wedges were made without the extra foot of the base and one gave trouble by loosening.

A set of wedges, comprising a drive, a pilot, and a deflecting wedge, cost about $25 in 1918. The average cost of a wedging was about $250, labor $100, fuel $50, carbon $50, wedges $25, and miscellaneous $25. Experienced crews took five shifts to complete a wedging, a shift placing a wedge, one shift drilling with "E" bit, two shifts reaming "E" hole to "A" size, one shift reaming through the wedge with the "A" bit.

Credit for the many suggestions is due the members of the firm of Smith & Travers, contractors. A successful wedging method, in addition to overcoming curvature, can be used to branch a hole for any purpose, for securing additional records of strata or additional samples of the vein or deposit. The application of wedging to the correction of curvature appears to overcome one of the large limitations of the diamond drill.

Method of Building Railway Track Across a Lake

In a recent extension of the Chicago Surface Lines southward to reach an industrial section located in Hegewisch, it was found advisable to locate the line through a swamp and a shallow lake. The 6-mile stretch of line was built in an unusual way despite great difficulty and danger. As described in Electric Traction, the method of construction consisted in first making a sort of a raft of old timbers and telegraph poles. The old second hand telegraph poles were placed longitudinal with the track and to these were fastened crosswise old ties or timbers. This material was brought up to the front on the newly constructed track and was floated into place. Continuing with the cribbing method, old ties and timbers were fastened to the raft until the cribbing extended about three feet above the water. The rails were then laid at standard gage on this cribbing and center dump cars were used to build up the embankment with slag, placed through the openings in the cribbing. Slag for this purpose was obtained from a nearby industry. This material proved much more satisfactory than sand or earth fill, as there was several feet of soft muck on the bottom of the lake and this spread out beneath the slag a considerable distance each side of the track. It is believed that sand or earth would have spread out a greater distance, thus requiring a greater amount of filling to complete the embankment.

When sufficient slag had been placed by means of the center dump cars, side dump cars were utilized. This method resulted in placing the slag on either side of the track forming the initial roadbed. The ties were then placed on the roadbed and the rails were removed from the cribbing and replaced on the newly laid ties. This method was repeated rail by rail until the track across the lake and swamp was completed. Once across the swamp, the ordinary methods of track construction were adopted.

It is interesting to note that as the work proceeded through the swamp, it was found possible to successfully reclaim about 50 per cent of the old timbers and poles used for cribbing, so that for each length of track built some of the original timbers were being used. The manner in which these timbers came floating to the surface of the water after having carload after carload of slag unloaded on top of them and being imbedded in the embankment so that they could not be seen, was an interesting feature of the work.

Another economical feature of the work consisted of using for track ballast the excavated material from another part of the line. The street at this point was a paved macadam roadway and the excavated material from this portion of the line was used as filling for the tracks at a railroad crossing, where it was necessary to grade the tracks to meet the railroad, a 1 per cent grade being used.

Owing to the adverse conditions encountered by the fact that the greater part of the extension had to be constructed through a swamp with water from a depth of 1 to 3 ft. and below the water a mass of soft mud or muck several feet in thickness, the progress of the work was necessarily much slower than on ordinary track construction. According to soundings taken, this muck was found to vary from 3 to 9 ft. in depth. Below this a sound bottom was found.

Considering the conditions under which the work was carried on, it is remarkable that there were no accidents and that the derailment for the entire job consisted only of two wheels off the track.

Present Day Painting Practice in Railway Field

From various papers presented before a recent convention of the Master Car and Locomotive Painters' Association we have taken the following as representing present day practice and the accumulated experience and judgment of some of the master painters and foremen painters in the railway field:

The chemical testing of varnish or paint materials has up to date been of little value as a reliable source of information, especially as regards durability. In fact, up to date, except in the case of raw materials, a chemical test is of no use to the painting department. The experienced painter by a few practical tests, such as elasticity, working and drying can usually determine and foretell through his experience the possible durability of the article in question.

For some time past the railway paint shops have been receiving many paint oils as substitutes for linseed oil. It is believed there is none, as yet, equal to linseed oil as paint making oil. A paint oil as a substitute for linseed oil for use in the railway paint shop can be made, and is being made and sold by many companies, on a linseed oil base, and of the same gravity. This dries with a good gloss, as it contains enough of volatile oils as conveyers to assist materially in the application of the paint and when evaporated in drying, leaves a thoroughly elastic and highly protective oil film in combination with the pigment. This paint oil can be used in thinning out paints of any character, oxide, carbon, lead or zinc, where oil is desired as a thinner without danger of any chemical action. Such oil would probably be called a combination oil.

Vegetable oils are used by many in making up their paint oils, namely, cotton seed oil, soya bean oil, hempseed oil, corn oil, peanut oil, cocoanut oil, etc. These vegetable oils being largely food oils and used extensively in paint making oils as substitutes for linseed have found an increasing market. Mineral oils are also used in the paint oils to some extent, but it is not advisable to be too free in the use of paraffin oils. Owing to the great demands for linseed oils and the scarcity of the supply, also prices soaring up almost to a prohibitive figure for general use in the paint shop, substitute oils have found a place in making paint oils for use in the railway paint shop.

There are quite a number of these, drying, semi-drying and non-drying, and not a few have their special uses in paint. The most important of the drying variety is China wood oil or tung oil. Poppyseed oil is prominent for grinding the finer grades of zinc white and artists' colors, and must be classed among the drying paint oils for the reason that when pressed from ripe seed it dries very nearly as rapidly as raw linseed oil. The reason for the use of poppyseed in colors or paints is due to the non-darkening of this oil and its free spreading. Bombay nut oil was at one time largely offered at a price somewhat lower than poppyseed oil. It was very clear, almost water white, and its drying property fully equal to that of bleached linseed oil. However, this oil has not been heard from in the market for some time.

Sunflower seed oil is also classed among the drying oils, but it has not found its way into general commerce and therefore nothing more is known about it than has been ascertained in an experimental way. Hempseed oil also belongs to the class of vegetable drying oils, but this seed being raised principally in Russia and a few other localities in Europe, is used mostly there as a paint oil; and if any is brought to this country it comes as an admixture with linseed oil.

Another vegetable drying oil that has been largely imported for some time into this country and Europe, under the name of candle nut oil by soapmakers and known to science as Kukui oil, is now being tested by progressive varnish and paint manufacturers. It bids fair to be a strong competitor of linseed oil when its characteristics become better known to the trade and it is prepared in a more scientific manner than it is now. Other drying vegetable oils, as nigerseed oil, tobacco seed oil, Scotch firseed oil, etc., that are not readily obtainable in commerce, are not at all interesting to the paint maker and color grinder.

Another oil, which is of animal origin, is the fish oil known as Menhaden oil. This is barred out, however, from use in many paint materials, especially in interior paints, because of its offensive odor, and is made use of only in special outside paints as in roof paints and stack paints, and by some manufacturers in other specialties.

Among the substitutes for linseed oil that interest paint manufacturers most should be classed soya bean oil, corn oil, and cottonseed oil. Soya bean oil requires fully ten days to dry to a film and then the film will not be as firm as raw linseed oil, which requires six days to dry to a film. Since linseed oil is extraordinarily high priced, there is quite a demand for bean oil and it is quite a task for paint makers to discover methods to make their products dry in the ordinary way. The usual practice was to use equal portions of soya bean oil and boiled linseed oil, or when this would not work out well in some paints the bean oil portion was increased and also the driers.

Corn or maize oil has been in use in paints for many years, but is made use of only when the linseed oil is high in price. This oil has very little, if any, drying properties, and will harden to a brittle, rather mealy film in from twenty to thirty days. Cottonseed oil has no drying properties, but is a good lubricant, and previous to its rise in price when it came to be used as a cooking and table oil, it was used to adulterate linseed oil. Rosin oils are not only used in printing-ink making, but were largely employed in making paint for rough surfaces, though since their price has advanced to twice, even three times their former cost, they have been replaced by mineral paint oils to a great extent in paint. Rosin oils are practically non-drying, and while they harden in time will soften again under the influence of sun heat and make the paint film part, or alligator. Pine oil and tar oil are products from the distillation of wood spirit and of rosin, and are used in the manufacture of marine paints, especially paints for ships' bottoms. These oils are semi-drying and water resisting to a degree.

Mineral paint or paint and putty oil, so called among the trade, is refined petroleum or neutral oil, so named because debloomed. These oils cannot be used without being mixed in certain percentages with boiled linseed oil, as they lack binder and are apt to wash off the surface in case of driving rains. Even when used in large portions in a liquid paint for rough surfaces such paints have been known to wash off when they were supposed to have dried hard a month or two before.

Petroleum products of this class will sweat, causing softening of the film and consequent damage by water.

Cheap paints for use on rough lumber or other rough surfaces can be made by grinding the base in linseed oil (usually boiled) thinning with a mixture of about 35 gal. of gloss oil (rosin and benzine mixture), 10 gal. of raw linseed oil and 5 gal. of liquid drier. Or if it must be still cheaper, a thinner can be made of 30 gal. of gloss oil, 15 gal. of debloomed neutral paraffin oil and 5 gal. of lead and manganese drier. In any case, however, the pigment to be used as the base for the paint should be ground in linseed oil.

So far linseed oil has not found an equal in paint making, although the subject has been one of deep study, and while other fixed oils have been discovered that for certain purposes have been expected to take its place, it has yet to be demonstrated that such is really the case in long practice. China wood or tung oil, while superior to linseed oil in certain directions, especially in its resisting power to water, has not shown itself adapted to replace linseed oil in making oil paints as we know and desire them.

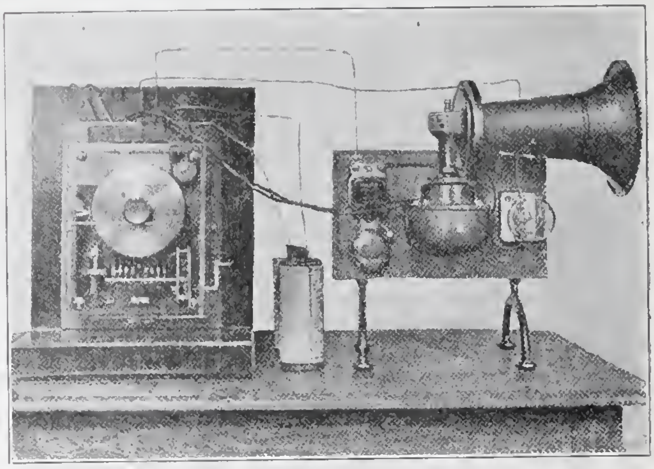
When linseed oil is placed on a strip of glass that has been painted jet black and shows a bloom, or iridescence, it is adulterated with mineral oil or rosin oil. Admixtures of linseed oil and corn oil or linseed oil and cottonseed oil can be detected by placing some of the oil between the palms of the hands, rubbing briskly and noting the odor thus emitted. The presence of soya bean oil, however, cannot well be ascertained by simple tests, and a chemical analysis is necessary though even that is sometimes misleading.

It was stated by one master painter that mineral oil should not be used with putty as it evaporates and leaves a powder that soon flakes off, affording no protection for the glass. Good putty effects a saving of glass and labor many times greater than the increased cost of the material.

Advantages of the Electric Horn for "Paging" Employees

In a paper presented last spring before the Rochester, N. Y., section of the American Institute of Electrical Engineers, V. Karapetoff, Professor of Electrical Engineering at Cornell University, points out the advantages of the electric horn with code systems over the ordinary telephone for notifying employees when they are wanted. The system is used in industrial plants and is applicable to mines and possibly to construction operations. An abstract of the paper follows:

A private telephone system, however extensive, promptly establishes communication with any important employee only so long as the needed man is at his desk. As soon as he leaves his desk the problem of finding him becomes a hit-or-miss proposition. On the other hand, a superintendent, a foreman, or a repair man is ordinarily useful only in so far as he can move about the plant or property freely, without the fear that someone of importance may need him.



Electric Signal Horn Apparatus.

An electric signal, similar in construction to the familiar electric "horn" used on automobiles, can be introduced for notifying heads of departments or foremen when they are needed at the head office. It consists of a diaphragm with an anvil at its center. A toothed wheel driven by a small electric motor strikes the anvil many times a second and causes it to vibrate vigorously. The device is provided with a projector or horn, the shape of which depends on whether it is desired to scatter the sound, to intensify it in a horizontal direction, or to deflect it downward. Such motor-driven signals are now made much more powerful than automobile horns, and are wound for 110 or 220 volts, direct or alternating current, so that they can be connected to a lighting or power circuit, and do not require a separate low-voltage battery.

When someone who may be anywhere in the plant is desired, the telephone operator simply sounds this particular man's call, whereupon he comes to the nearest telephone, and reports, and the operator then connects him with the person at the other end. A special code-calling automatic instrument has been developed for this purpose. The operator merely sets the desired person's code number on a dial and pulls a lever. A contact-making mechanism is thereby set in motion, which closes the electric circuit and operates the code signals throughout the plant the required number of times (usually three times) and it stops automatically.

A further application of loud electric horns in industrial plants is for extensions to telephone bells. The ordinary telephone ringer is not loud enough in many shops when the foreman is away from his desk. In this case, a relay is connected in parallel with or in place of the telephone ringer, and when it is actuated it closes a secondary circuit, which causes an electric horn to sound. This call should be a single blast, to distinguish it from code calls.

A modern coal mine may have miles of passages and rooms underground, so that the superintendent and his assistants have to cover an extensive area. A system of powerful horns installed throughout the mine and connected to a code-calling instrument outside the mine would instantly convey any call, and the superintendent or whoever is called, would come to the nearest telephone and report to the operator.

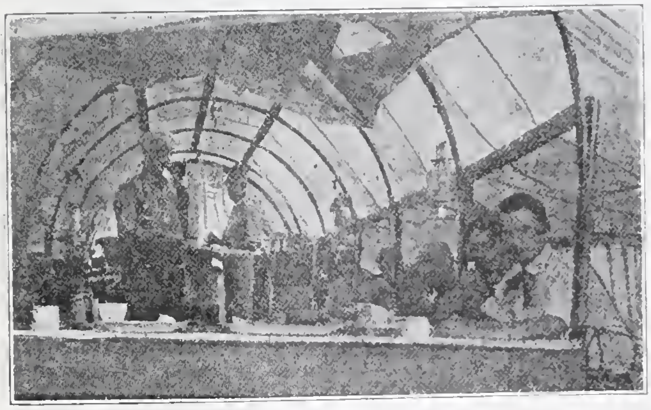
A further improvement of this system might consist in providing the superintendent, the foremen, the electrician and others with portable telephones, which could be connected to the line wires at any point. This is possible in many mines in which bare steel wires are used for the telephone circuit. In some mines, especially where rope haulage is used, the man on the train is given a piece of metal with which he short-circuits these two wires, and cause a signal gong to ring at the winding engine. In this case the telephones are connected through condensers, and electrical connections are used similar to those which permit simulataneous telegraphy and telephony over the same wires.

The same acoustic signals may be used for sounding emergency calls or for a general alarm, although the exact arrangement would have to be worked out separately to meet the conditions in each individual mine.

Wagon Camps for Housing Construction Crews

In building a transmission line from a central station in St. Petersburg, Fla., to Clearwater, Fla., considerable economy was affected by providing portable camps for the construction force. The following description is taken from an article by Carl L. Raymond in the Electrical World:

The construction commenced in September with a crew of 18 men. The crew was divided into three gangs—one framing the poles (which had been distributed as fast as received), putting on cross-arms, bayonets for the ground wire and insulators; the second digging holes, and the third erecting poles, a gin wagon being used for this latter work. The wire was not strung until after the poles had all been erected, which enabled the use of a smaller camp than would otherwise have been required, the same equipment serving both crews. The right-of-way, which was practically free from underbrush, was cleared just ahead of the wire crew.


Inside of Mess and Commissary Wagon.

The camp equipment was composed of three camp wagons fashioned after the prairie schooner, two for sleeping and one a combination cooking and dining wagon. The sleeping wagons consisted of enlarged wagon beds mounted on standard running gears extended, sheltered by heavy, waterproofed canvas stretched over light framework rounded on the top and supported by seven light stanchions and struts down the center of the wagon. This divided the sleeping space into eight individual bunks, each being equipped with a mattress. Ventilation was secured by fastening the canvas a few inches outward from the floor, all open spaces being covered with mosquito netting, including the ends of the wagons. The end netting was made in the form of flaps, allowing free passage.

The commissary wagon was built similarly but without center stanchions or struts, and the canvas on the sides was arranged to be raised outward for awnings. In the center of the wagon was an aisle on the sides of which were elevated platforms covered with oilcloth that served as tables. At meal time the men drew up on the outside, sitting on light portable benches. At one end of the aisle, a little to one side to allow passing, was a wood burning cook stove and at the other end was a built-in ice chest. The non-perishable commissary supplies were stored under the "tables." Considerable economy was effected by this portable camp, as it was easily moved by three men and one team and the crews seldom had to walk more than a few hundred feet.

The Railroad Labor Supply

Mr. Hugh Reid of the U. S. Dept. of Labor, in speaking before the recent roadmasters' convention in Chicago, gave some interesting figures concerning the labor outlook for the future. He pointed out that there are approximately 37,000,000 persons in gainful occupations in the United States, nearly 11,000,000 of whom are engaged in farming. Of the remainder approximately 3,594,000 are unskilled. The United States is a consumer of unskilled labor, converting it into skilled artisans. Its supply of unskilled labor comes almost wholly from abroad.

Previous to the war over 1,000,000 immigrants entered the United States annually, of which approximately 600,000 were unskilled. Following the outbreak of the European war, this immigration was reduced to 25 per cent of normal at once and in 1918 and 1919 it was only 9 per cent of the prewar figure, while in the latter years the percentage of unskilled labor to the total fell from approximately 50 per cent to less than 25 per cent. During the war large numbers of unskilled men also returned to their homes. With immigration shut off, a swirling movement of labor was set up in the United States, as a result of which about 600,000 negroes came north, creating crop shortages in the south.

Speaking of the future, Mr. Reid gave it as his opinion that no one could forecast accurately what may develop. The index to immigration to America is the industrial situation in Europe. He did not anticipate any great immigration immediately because of the expense and difficulty in reaching our shores. In his estimation the great problem is not that of the shortage of labor, but of its distribution. Because of the surplus which has ordinarily prevailed, the United States has never had to develop an elaborate system of labor distribution such as has been built up in Europe in the form of public employment exchanges.

In conclusion he stated that it was his belief that the labor situation will remain practically as it is now insofar as it may be affected by conditions outside of the United States.

Recommended Salaries for Baltimore Engineers.—The Baltimore Chapter of the American Association of Engineers presented to the Board of Estimates of the city of Baltimore, under date of Sept. 27, a report of the compensation committee of that chapter on salaries of engineer employes of the city, with the request that the board analyze the situation and take such action as seems advisable. The schedule recommended covers more than 60 grades of engineer employes of the city. It recommends an increase for the chief engineer of at least $2,500 to bring his salary up to a minimum of $10,000 per annum, with a maximum of $15,000. Some of the other recommendations are tabulated below:

Present title.	Present annual salary	Annual salary recommended by committee Minimum	Maximum
Highways Engineer, Water Engineer, Harbor Engineer, Chief Engineer Paving Commission and Inspector of Buildings	$4,000	$5,000	$7,500
Division Engineer of Sewers	3,300	3,600	5,000
Principal Assistant Engineer Water Department	3,000	3,600	5,000
Mechanical Engineer, Water Department	2,700	3,600	5,000
Assistant Engineer, Water Department	2,200	2,700	3,300
Assistant Engineer of Bridges and Improvements, Highway Department	2,000	2,700	3,300
Designing Engineer, Water Department	1,800	2,700	3,300
Assistant Engineer, Grade AA, Water Department	....	2,400	3,000
Office Engineer, Paving Commission	2,000	2,400	3,000
Field Engineer, Highways Department	1,500	2,400	3,000
Draftsmen, all departments	1,500*	1,500	2,100
Instrumentmen, all departments	1,200	1,500	2,100
Rodmen, all departments	1,020	1,200	1,500
Tracers, all departments	840*	1,080	1,200
Chainmen, all departments	900*	1,080	1,200

*Maximum.

Methods of Constructing Hydraulic Fill Dams of Miami Conservancy District

In connection with its flood control project for the Miami Valley, Ohio, the Miami Conservancy District is now constructing five retarding basin dams involving about 8,000,000 cu. yd. of embankment. The greater part of this yardage will be hydraulic fill, making the work the largest of its kind yet undertaken. An excellent description of the methods employed in constructing these dams was given by H. S. R. McCurdy, division engineer of the district in a paper presented last month at the convention of the New England Water Works Association. An abstract of the paper follows:

Stream Control.—The first important consideration in the program of construction was the problem of stream control. These dams are situated above large centers of population, where any sudden release of impounded water would spell disaster. Therefore, the sequence of operations must be so planned as to be safe beyond a reasonable doubt even should a repetition of the great 1913 flood occur. This is done in two ways, depending upon the type of outlet works. At Lockington, Huffman and Taylorsville the outlet works are simply openings through the lower portion of the spillway weir. It is, therefore, a simple matter to construct the bottom and side walls of the structure, making an admirable flume for the passage of water. The weir itself is not built in until the dam has reached a safe height.

For the covered conduit type of outlet works, as at Englewood and Germantown, however, the stream control problem is vastly more difficult. Here it is necessary to retain the original waterway or provide an artificial one until such time as the adjacent portions of the dam can be carried up to an elevation of safety, and subsequently to make the closure during the season of low flows. At Germantown the problem is simplified by the narrow valley and the yardage involved in raising the embankment clear of the danger point is sufficiently small to permit the river closure to be made this season. In fact, the work is now going on. These closures are, of course, greatly facilitated by the temporarily increased capacity of the conduits.

At Englewood the stream control problem is somewhat complex. The country is so flat that a closure entirely across the river valley during one low-flow season is not to be thought of. The alternative, therefore, lies in what amounts virtually to building the dam in sections. The first season a cross dam is built on the east bank of the river. This cross dam is nothing more or less than a short section of the main embankment built from toe to toe to serve as a retaining wall for the end of the hydraulic fill. Where this end dam lies within the outer portions of the main embankment it is built up of porous material; where it crosses the middle portion of the main dam impervious material is used. Thus the composition of the main dam from end to end is not interfered with by the fact that the cross dam is interposed. The cross dam is carried up only fast enough to keep well clear of the hydraulic fill. Where within the center portions of the main dam the material for the cross dam is pumped into place integral with the main hydraulic fill. The central portion is rolled in 6 in. layers using a 12-ton steam roller.

With the cross dam in place to elevation 840 something over 1,000,000 cu. yd. of hydraulic fill can be pumped without disturbing the river channel. This is a good season's work. In the meantime west of the river a temporary spillway, guarded on the east by a cross dam carried to elevation 850, will be constructed and next April, with about 11 months of immunity from severe floods ahead, the river closure can be made and the hydraulic fill carried up to elevation 850. The third season sees a comparatively easy closure of the temporary spillway and no further worry from flood flows, even should a repetition of the 1913 flood occur. The dams should be completed the fourth season.

Hydraulic Fill Material.—At all the dams the material for the hydraulic fill comes from the river valley upstream and consists of a modified glacial drift. A slight exception to this occurs in the case at Taylorsville, where glacial fill from the excavation for the spillway, so long as it lasts, is being pumped into the dam.

In cross section the outer portions of the dam are composed of cobbles, gravel and sand and the central core of silt and clay. In the interests of safety the width of core in all the dams is confined to comparatively narrow limits. Such a procedure does not entail any particular hardship, inasmuch as the modified drift from the borrow pits contains roughly the desired proportion of clay. At Taylorsville, however, where the dam at present is being built of glacial till from the spillway excavation, the proportion of clay is so great as to necessitate some wasting from the pool. For simplicity the width of core has been arbitrarily taken as zero at the top of the dam, with slopes of 2 on 1. Thus the width at any elevation is equal to its distance down from the top. Expressed as a fraction of the width of dam the core as placed would amount to about one-sixth. No particular justification can be advanced for adopting precisely this ratio, excepting to say that in the minds of the engineers it represented a structure eminently stable against sloughing and at the same time one that contained sufficient core to be impervious against impounded water. Very conveniently the adopted proportion of core coincides with the "fines" in the material from the borrow pits. This may not be entirely a coincidence. Hydraulic fill is in progress at this writing (Sept. 1) at Englewood, Taylorsville, Germantown and Lockington dams. Huffman has a big railroad relocation problem on its hands and will not be ready to pump dirt much before next year.

Dragline Excavation at Borrow Pit.—The Englewood borrow pit is located upstream from the dam. The material is excavated by means of two 115-ton dragline excavators, one electric and the other steam, equipped wtih 85 ft. booms and 1½-yd. buckets. The draglines are ranged along the same track, about 1,000 ft. in advance of the other.

An interesting comparison is offered as to the relative merits of steam and electricity as power for machines of this type. With electricity at slightly less than 1.6 ct. per kilowatt hour, the steam dragline is somewhat more expensive. The latter is more rapid in operation, but the cost of coaling runs the unit cost above that of the machine using electrical power.

The depth of face in the pit averages perhaps 15 ft. and the draglines load into standard gage 12-yd. air-dump cars. Under these working conditions each machine can comfortably move from 150 to 180 cu. yd. per hour. A double track system is arranged, with suitable crossovers, in such a manner that no interference occurs in the handling of trains.

There are four trains from the borrow pit containing 7 cars each, which are handled by 40-ton locomotives. They climb a 2 per cent compensated grade into a trestle 175 ft. long paralleling and close to the upstream toe of the dam. From the trestle the car dumps into what has been given a name more practical than euphonious: "The Hog Box."

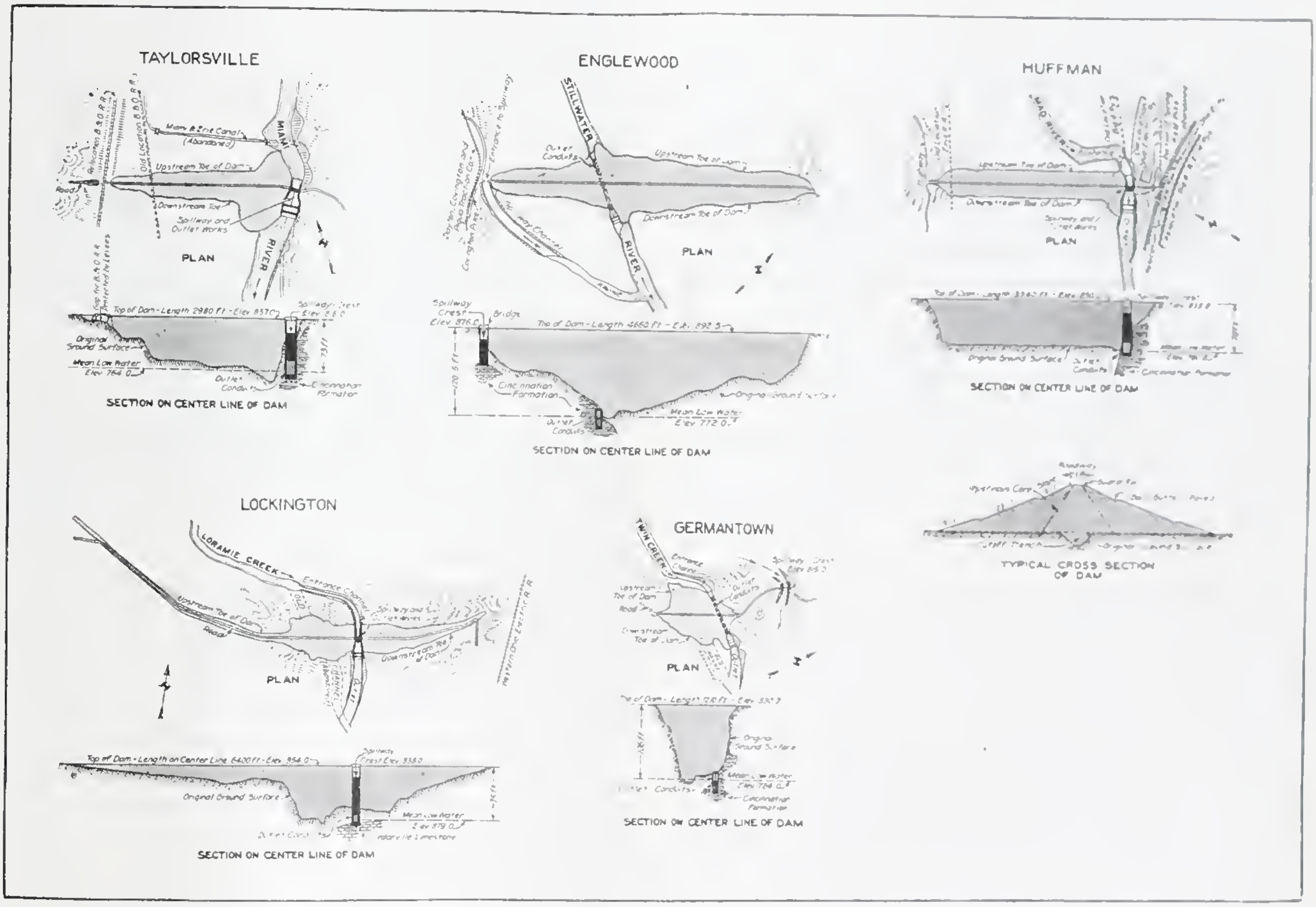
Revolving Screens Eliminate Oversize Rock.—The hog box is essentially a trough 150 ft. long and 27 ft. wide ranged alongside the track from the borrow pit, which, at this place, is carried on a pile trestle. The floor of the hog box is 13 ft. below the rail and cones at approximately 4 per cent to an opening in the opposite side from the track. The opening discharges into revolving screens through which the material passes to the sump. The sump is a concrete well, 8 ft. by 16 ft., divided by a partition into two chambers 8 ft. square. The floor is 16 ft. below the floor of the hog box.

The material as dumped from the trains into the hog box may be dry or wet, according to whether the draglines happen to be digging above or below ground water level. As the material lies in the hog box it is washed through the revolving screens into the sump by means of two hydraulic giants or monitors, one at each end of the hox box. Pressure for this sluicing water is furnished by two 10-in. centrifugal pumps, operating at a speed of 1,140 r.p.m. and each driven by a 100 h.p. motor. The pressure is maintained at approximately 60 lbs. and the jet is directed through a 3-in. nozzle.

The revolving screens are the product of several rejected schemes for eliminating the oversize rock from the material being fed to the dredge pumps. At first sloping gratings of several types with square openings were tried. These were fairly satisfactory when the material was not coming too fast or when there was not too great a proportion of clay lumps. At such times the tendency was for the gratings to clog. Furthermore, each grating required the services of three men, clearing away the material. But the revolving screens seem to have effected a complete and simple solution of the rejection of oversize.

The screens are cylindrical in shape, 4 ft. in diameter, have an effective screening length of about 9 ft. and are pierced with 6 in. circular holes in one case and 6½ holes in the other. The latter size is in the last screen installed and is an attempt to use the largest size openings possible without choking the dredge pumps. While the 6½ in. holes are satisfactory it is not known as yet whether or not this size can safely be increased. The screens pitch ½ in. to the foot.

The first screen installed was given a speed of 14 r.p.m. but in its companion, installed later, the speed has been reduced to 9 r.p.m. and seems to give, if anything, more efficient surface. Each screen is operated by a small electric motor, belt connected, the reduction in speed being accomplished through a countershaft. From the screens the acceptable material drops directly into the sump, while the oversize rock goes out of the end into bottom dump buckets which are hoisted out with a stiffleg derrick and dumped into a standard car in which they are hauled away to the downstream slope of the dam.


TAYLORSVILLE
PLAN
SECTION ON CENTER LINE OF DAM
ENGLEWOOD
STILLWATER
RIVER
PLAN
SECTION ON CENTER LINE OF DAM
HUFFMAN
PLAN
SECTION ON CENTER LINE OF DAM
LOCKINGTON
LORAMIE CREEK
PLAN
SECTION ON CENTER LINE OF DAM
GERMANTOWN
TWIN CREEK
PLAN
SECTION ON CENTER LINE OF DAM
TYPICAL CROSS SECTION OF DAM

Plans and Sections of Retarding Basin Dams of Miami Conservancy District.

Not only do the revolving screens serve to reject the oversize rock but, in addition, they fulfill another most important function. The tendency of the giants, even with the most skillful handling, is to wash the material into the sump in masses. Thus, one minute the dredge pumps would be handling comparatively clear water while the next they would be staggering to clear themselves of an overload. The action of the revolving screens, however, tends to rectify this irregular feed and to deliver the material to the suctions of the dredge pumps in a uniform flow.

It is of the utmost importance that the delivery of the mud to the pumps be as uniform as possible. A neglect of this precaution has a most dire effect upon the output. Directly beneath each screen is an inverted truncated pyramid with an opening 2 ft. square directly above the suction of the dredge pump. The object of this is to remix the fine material passing one end of the screen and the stones passing farther on. The suctions from the dredge pumps are inclined at an angle of 45° from the vertical and, in order to lead the material to them along the easiest lines the floor is shaped as an inverted pyramid. It has been found that with a flat floor the mud has a tendency to pile up until at some point a great mass will slough off and bury the suction. Then comes the plug and a vexatious delay until the suction pipe is cleared.

The Business End Hydraulic Fill Plant—the Dredge Pumps.—At Englewood the present installation comprises two 15-in. centrifugal pumps, designed for 150 ft. head operating at a maximum of 505 r.p.m. and each driven by a 500 h.p. slip ring induction motor. These pumps are made of cast manganese steel, containing perhaps 5 or 6 per cent of manganese (although the makers have not disclosed this). As yet this particular alloy seems to be by far the best fitted for standing the abrasive wear of sand and gravel. The shell of these pumps is from 2½ to 3 in. in thickness, depending upon the place.

An item of the utmost importance is the design of the impeller, a matter which is complicated by the range of head against which the pump is called upon to operate. For instance, at Englewood the dredge pumps are working under heads which at the beginning are not more than 25 ft., but which are steadily increasing until a maximum of 150 ft. shall be reached, at which point a booster pump will be inserted in the line. To compensate for this variation different size runners are being tried, a smaller one for the lower heads and increasing in size as the heads shall increase. This arrangement is adapted to develop more fully the power of the motors. With the large runner against low heads a large percentage of horsepower is wasted in overheating the grids. Diameters of runners of from 38 in. to 46 in. are being tried, but as yet it is too early to state results. The matter is, however, one of vital importance and will be carried along to definite conclusions.

The life of one of the manganese steel pumps as at present designed, pumping sand and gravel, is slightly less than 200,000 cu. yds. At Englewood the second pair of pumps is now in service, but the designers are making modifications in design for future deliveries from which are expected better results. The impellers show wear at 50,000 cu. yd., but can be used, with doubtful efficiency, for perhaps 100,000 cu. yd.

The consensus of opinion among those studying the operation of the pumps is that it does not pay to use equipment after it is badly worn. Economy is better served by scrapping the old shells and runners the moment they show signs of letting down. Inasmuch as the dredge pumps are the neck of the bottle, and the entire organization is succeeding in its purpose only to the extent that the pumps are functioning, it is obvious that they should operate at the highest pitch. To increase the life of the impellers renewable shoes, for the wearing parts, are being tried.

The operation of the dredge pumps and monitor pumps requires about 31 c.f.s. of water. The location of the sump is 450 ft. from the river. Rather than pump the water this distance a 4-ft. corrugated iron culvert was laid through which the water flows by gravity. Near the sump a concrete well was built in the line to serve as a sump for the monitor pumps. Each of the two monitor pumps handles 2,000 gal. per min. The nominal capacity of each dredge pump is 7,000 gal. per minute, which latter figure is the amount to be provided for, inasmuch as the discharge from the monitor pumps feeds into the sump.

Pipe Lines and Method of Ensuring Even Wear.—The dredge pumps pick the material up from the sump and discharge it to the dam through 15 in. pipe. Where the pipe line runs up the side of the dam, and is therefore more or less permanent, the heaviest class of standard cast iron flanged pipe is used. For the shore lines, however, where the pipes are changed for each run, a lighter pipe than the cast iron one that can be handled with rapidity and ease is required. For this purpose one of the large rolling mills is manufacturing a special welded manganese steel pipe. This metal contains 0.50 to 0.60 per cent carbon and 0.60 to 0.70 manganese, which limits are imposed by the rolling process. The pipes are slip joint, i. e., have a slight bell on one end and are held together by wire stretched over hook lugs. The thickness of shell is 11/64 in., the pipes are in 16 ft. lengths and weigh 2,883 lbs. per lin. ft. It is not known to date just what the life of these manganese steel pipes is, for the very good reason that, to date, none has worn out.

The greatest yardage that any of the pipes have passed to date is about 300,000. Riveted steel pipe, made from ordinary steel plate containing 0.10 to 0.20 carbon proved very short lived. Claim has been made that the manganese pipe will last 10 to 15 times as long as 0.15 carbon steel and this may prove to be so.

To insure an even wear around the circumference of the pipe they are turned 120° for each new run. Observation shows that practically all of the solids flow within the lower third of the pipe, the upper two-thirds being filled with water bearing only the lightest particles. Consequently, for a given run it is the lower portion of the pipe only which is subjected to any considerable wear. No difficulty is experienced in practice in doing this: one end of each pipe is numbered 1, 2 and 3, 120° apart, and each time a line is relaid the pipes are revolved until the next number is uppermost.

Co-ordination of Operations in Pumping Earth Materials.—The trick in pumping earth materials seems to lie in developing the consistent maximum capacity of the pumps and then feeding them uniformly to that capacity and no more. If the pumps are not receiving all the solids they can handle money is being wasted. If, on the other hand, the pumps receive more than they can handle for any considerable time a plug ensues and the entire pumping outfit spends many profane hours in clearing out the pipe, not a pleasant or easy job at best.

Of course, short overloads, if not too heavy, can be handled by the reserve power in the motor, but there is a limit to the length of time this reserve can be applied without injuring the motor and also a limit to the amount this power can handle. The whole method involves a synchronizing of effort on the part of the monitor men and the pump runner. Either working without due regard to the other can waste efficiency or plug the system. If the pumpman does not throw in an extra finger on the switchboard at exactly the same time that the monitor men are crowding the dirt, trouble ensues.

At Englewood the first plan for co-ordinating the various operations consisted in establishing a control tower overlooking the hog box. Here were installed pressure and vacuum gages, electric bell connections to pumpman and monitor men, and connections with portable telephones at the end of the pipe line. By his electric gong signals the foreman in the tower could direct operations—signal the monitor men for more or less food as the case might be, or notify the pumpman to increase his power. This was a big advance over anything tried before, but it had one weak spot—the gages in practice did not always operate as swiftly or as surely as was desired. Sometimes the line would plug before the gages had given warning.

The difficulty has been solved by a very simple little device. The first sign of plugging in the pipe is manifested by a reduction of velocity. This at once becomes apparent at the discharges from the pipe line by a slackening of the issuing stream. With this in mind the resident electrician ripped up a small attachment consisting essentially of a steel clapper working on a hinge and forming contact at one end with an insulated wire running to the pump house and at the other end with the jet from the pipe.

The theory of the contrivance is that with a full jet issuing from the pipe the clapper is pushed against the contact points and the circuit is closed, but as the jet falls the contact breaks and the circuit is opened. Connected in the circuit are incandescent lamps, one at each monitor and one at each pump. Thus the monitor men and the pumpman are constantly and instantly informed as to the condition of flow through the pipe and can govern themselves accordingly. This simple device has resulted in a marked increase in the output and has borne a large share in the elimination of plugs.

In building the dam the pipes are ranged along the toes of the slope. As the material builds up pipes are added, a 16 ft. length at a time, until the end of the run is completed. The line is then taken apart and a fresh start made, each run being 4 ft. higher than the previous one. Upon issuing from the pipe the coarser material tends to settle first, leaving the finer to be borne by the flowing water toward the central pool. On reaching the edge of the standing water, or slightly farther, depending upon the velocity, all coarse particles are immediately precipitated on a slope of about 1 to 1. Beyond this nothing is carried but silt and sand. It will be seen, therefore, that the width of core is dependent upon the width of pool, provided, of course, that the material being pumped contains a sufficient percentage of "fines" to make a core of the desired width. If more than this occur the excess clay must be wasted with the outflow from the pool.

In the advance of the pipe line, to prevent a portion of the discharge from flowing down the slope of the dam, a levee is thrown up. At Englewood this is done by means of 35-ton steam dragline excavators, mounted upon caterpillar tractors, one operating just in advance of each pipe line.

Slope of Fill.—The slope of the fill from the pipe line toward the pool is dependent upon the coarseness of the material and the percentage of solids in the discharging stream. For the Englewood material this slope ran uniformly at approximately 6 per cent for several months. During August, however, with an increased output, the slope has jumped up to about 7.75 per cent. A small amount of the water entering the pool seeps out through the gravel, appearing as small springs along the toes of the dam. The greater portion, however, must be led away in some form of wasteway. The method in use at Englewood is to dig a ditch about 8 ft. deep at one end of the pool, following the contour of the hillside. In this ditch a small earth dam is built through which are laid some old 20 in. dredge pipe. A wooden paddle serves as a gate for each pipe. Each spillway, progressing up the hillside, serves two runs, or 8 ft. in elevation of the pool.

Core Material and Behavior of Core.—As previously stated, the material in the outer portions of the dam is composed of cobbles from 6 in. diameter down to gravel and sand. At the "drop off" just inside the shore line of the pool, the grading changes to sand, quickly diminishing in size to silt and clay. An analysis of the core material, made by the Bureau of Soils at Washington, showed the following gradation:

Material.	Sieve.	Per cent.
Fine gravel	2 to 1 MM.	0
Coarse sand	1 to 0.5 MM.	0.4
Medium sand	0.5 to 0 25 MM.	0.3
Fine sand	0 25 to 0.1 MM.	4.6
Very fine sand	0.1 to 0.05 MM	19.6
Silt	0.05 to 0.005	52.7
Clay	0.005 to 0	22.6

Studies are being made as the dam progresses of the behavior of the core. It is known that it is becoming stiff at the lower elevations. A 1½ in. diameter pole shoved into the core meets sensible resistance at about 15 ft. The stiffening increases until at 25 or 30 ft. a man's weight will force the pole no farther. It is the intention to test the rate of stiffening in the core by noting the penetration of a 6 in. cast iron ball. By this means a direct comparison can be had between the cores at the five Conservancy dams. Furthermore, this ball method was in use at the Calaveras dam for the Spring Valley Water Co. in California, and comparisons in penetration can be had with that dam. It is also the intention to insert in the core a number of pressure recording devices, developed by the Engineer of Tests, Bureau of Public Roads, Washington, for the purpose of measuring pressure in semi-fluid masses.

Friction Head in Dredge Pipe.—At the time the pumping plant was laid out very little authentic data were available in reference to friction head in dredge pipe. It was thought that, with the velocities of 12 ft. per second the loss of head would be about 4 ft. in 100 ft. In the clayey glacial till, such as is being pumped at Taylorsville, this is approximately true, but in the gritty sands and gravels at Englewood and Germantown, using velocities of 15 ft. per second or upward, it is found that the friction head is unexpectedly large, amounting to as much as 8 ft. per 100 ft. Such a condition throws a heavy penalty upon length of discharge line and accordingly, at Englewood, studies are being made to abandon the present sump late this season and to use, progressively, three other sumps so located as to reduce both static and friction head to the least amount compatible with securing a satisfactory railroad grade from the borrow pit.

A matter entering vitally into the rate of progress of the hydraulic fill is the per cent of solids in the water handled by the dredge pumps. At times clear water is being pumped: at others as much as 15 or 20 per cent of solids are carried for short periods. The present average is probably from 6 to 10 per cent. Obviously, the higher the percentage the lower the unit cost and studies are being made along these lines to find out just what can be handled. In the first place there is vast room for improvement in the sumps. A sump is now being designed at Englewood from which much is expected. The principle being followed is to drop the material passing the revolving screens into the path of the water flowing to the suction of the pump and to fashion the entrance to the suction into a bellmouth to reduce the loss of head at entrance. But it is one thing to get the material into the pump and another to pass it through along discharge line without plugging the latter. This feature is engaging the attention of the engineering force and studies are under way looking to some form of spiral or rifling device which will keep in suspension the solids in the discharge pipe and offset the tendency to settle in the bottom of the pipe.

Dredge Pumps Average 150 Cu. Yd. Per Hour.—The monthly progress at Englewood, working two 15-in. dredge pumps two shifts of 10 hours each, has averaged 100,000 cu. yd. Some minor changes in the screens and sump have lately served to increase that figure so that at present (Sept. 1) each pump is delivering consistently 150 cu. yd. per hour or a total for the two of 6,000 cu. yd. per day. The total amount placed to date aggregates approximately 650,000 cu. yd.

Hydraulic Fill at Other Dams of the Conservancy District.—This is following so closely the methods in use at Englewood that only the essential differences will be noted. At Germantown the material is to be pumped, the location of the borrow pit and the general arrangement differs in no essential from Englewood. The dredge pump motors are 350 H. P. instead of 500 H. P., but this is on account of the lower head against which they will be called upon to operate.

At Taylorsville, however, the problem at present is somewhat different. This dam requires an excavation of something like 500,000 cu. yd. of glacial till overlying ledge rock for the spillway. This till is high in clay, containing perhaps 50 per cent. The logical thing was to use the excavated material for the construction of the dam, and the easiest way, considering that a hydraulic fill dam was to be built, was to pump it into place. Accordingly, a pumping plant consisting of four 6-in. pumps, operated by 75 H. P. motors, was installed at a convenient place near the river. From here water is pumped through 15-in. spiral riveted pipe to the excavation at 130 lb. pressure and played upon the face of the pit by means of a hydraulic giant fitted with a 3-in. nozzle. More water is needed to convey the material than to break it down, consequently an 18-in. wood stave line is run to the top of the face under sufficient pressure only to flow freely. Water for this line is furnished by one 12-in. pump with 150 H. P. direct-connected motor. The high pressure nozzle handles 6.1 c. f. s., while through the low pressure pipe 12 c. f. s. are carried. The sluiced material flows by gravity down a rough channel into a sump from which it is pumped in a manner similar to that at Englewood into the dam.

The method of handling the levee ahead of the discharge pipe differs materially at Taylorsville from the dragline scheme described for Englewood. At Taylorsville the pipe as it comes into the dam, is separated by a Y into two discharge lines. The end of the pipe line nearest the slope is slotted in the bottom in such a manner that the greater portion of the solids runs out, building up a windrow beneath the pipe. A few laborers handle this material into the levee. As each length of pipe is filled up the discharge is deflected at the Y into the line nearer the center of the dam and flows through that line until an extra length of the pipe has been inserted and the "window" pipe again attached. While this method seems on the face of it to involve less expenditure than that in use at Englewood, it is not applicable at the latter dam, owing to the much greater output there.

But one pump is operating at Taylorsville and working one shift only. The reason for this seeming lack of haste is that they are not ready to begin building the dam in earnest at this time. The hydraulic fill is simply the logical way to handle the earth excavation and, in turn, the earth excavation is well ahead of the rock excavation, which latter is the key to the spillway construction and river diversion.

Life of Dredge Pump Impeller.—The dredge pump at Taylorsville is cast iron. At first 34-in. cast iron impellers were used in this pump, but they handled only from 6,000 to 10,000 cu. yd. These were replaced by 39-in. cast iron impellers which handled from 17,000 to 22,000 cu. yd. Manganese steel impellers, 34 in. diameter, fitted with 36-in. shoes, were then substituted and have handled to date 60,000 cu. yd. of material without showing undue wear. The original cast iron pump shell is still in service. The pumping at Taylorsville has averaged about 120 to 130 cu. yd. per hour with the one pump. To date approximately 150,000 cu. yd. have been placed. As nearly as can be determined the percentage of solids in the mixture being pumped to the dam average about 6.

The arrangement of the pumping plant at Lockington is somewhat similar to that at Taylorsville, although for an entirely different reason. There is plenty of suitable earth material well up on the hillside favorably located for placing into the dam. Furthermore, the old Miami and Erie Canal, a relic of 70 years ago, passes at one end of the dam at a high elevation. This portion of the canal can easily be adapted for a water supply. Taking advantage of these favorable circumstances a pumping plant, consisting of two 8-in. centrifugal pumps direct connected to 100 H. P. motors, was located at a high elevation, receiving water from the canal through a flume, and serving a hydraulic giant in the borrow pit at 60-lb. pressure. This giant breaks down the face of the pit and washes the material down a ground sluice into a sump. Here it is picked up by a dredge pump and forced through a 12-in. line into the dam. As yet the hydraulic fill at Lockington is only started and, beyond a successful beginning, little has been accomplished.

At the Huffman Dam an extensive scheme of railroad relocation has placed the hydraulic fill operations farther down on the program than at any of the other dams. It is expected that pumping will begin in the early spring of next year.

Lengthening Life of Hose on Suction Dredge.—A simple device employed on midwest sand and gravel dredges for preventing wear on 10-in. or 12-in. suction hose is described in a recent issue of Rock Products. On a suction intake end of the dredge is a crib of timbers surrounding the intake pipe. On top of these timbers is an arc of steel pipe about 2 in. in diameter and 6 or 8 ft. long. To the pipe intake beyond its connection with the flexible hose coupling is fastened a 10x10-in. square timber by means of two iron straps. The other end of the timber is free to move about the arc of 2-in. pipe as a fulcrum. The 10x10-in. timber carries the weight of the intake pipe and provides a universal joint at its connection to the dredge, which prevents load and wear on the hose coupling. This device lengthens the life of the hose many times over the usual connection where the hose takes all the wear and strain.

Methods for Obtaining Increased Efficiency in Track Labor

Mr. C. A. Morse, Chief Engineer of the Chicago, Rock Island & Pacific Ry., speaking on maintenance of way labor before the Roadmasters and Maintenance of Way Association, at Chicago, on Sept. 17, 1919, put into his address so much of sound common sense and human interest that we are reprinting it nearly in full:

There has never been a time in the past generation when it was necessary that there should be such radical changes in methods of maintenance of way, as is the case at the present time. We have always been able to get cheap labor, and have, in fact, used the cheapest class of labor on maintenance of way work. The result has been little incentive for the use of mechanical appliances or for being particularly careful that every hour of every man was put in to the best advantage.

With the cost of labor doubled and the wages of section foremen increased 50 per cent there opens up a big field for the careful study of the use of both man power and machinery in our maintenance of way work. There are, in my opinion, many advantages in this change in the wages of both section foremen and track labor. In the first place, there was no class of men on the railroads that, considering the responsibility that rested upon them, were so poorly paid as the section foremen. They were and are, responsible for the track on their sections 24 hours in the day, and a more faithful and loyal set of men, as a class, does not exist; and I, for one, was much pleased to see them get the increase in salary that they did.

Better Class of Labor Now Available for Track Work.—The low wages paid track labor gave us the poorest class of labor in the land, in fact—except in the country districts—we only got what was left after every one had taken the pick of the men, and we were breaking in much of the foreign labor that could not speak English. They worked on the railroad maintenance-of-way gangs until they could understand and speak a little English, and then the best of them left for work that paid higher wages. One result of this was that we were very short of material for making foremen, and on many roads they were putting on special apprentices at increased wages in order to train men for foremen. With the increase in price now paid we will be able to pick our men, and also to have plenty of timber out of which to make foremen; and the salary now paid the section foremen will make it an attraction to them.

The fact that we are going to be able to have a better class of men brings us another problem, which is, that of providing proper housing facilities. We have furnished little more than "flops" for maintenance-of-way laborers for years. Old car bodies, tie houses, anything that resembled a protection from the weather has been considered all that was necessary. The result has been poor sanitary conditions, half sick men and poor service. It is a good thing that something has come up to bring about a change in such methods, and we should all insist on good, clean, commodious, comfortable and sanitary quarters for track laborers. There should be sanitary cots, bathing facilities, good drinking water, lockers, where men can put their extra clothes and valuables, and room enough for men to assemble for games or reading in bad weather and on evenings and Sundays. There is no reason why a man working on the tracks of a railroad should not have a place to eat, sleep and rest that is comfortable and inviting and where a man can maintain his self-respect.

Ways of Getting Best Results in Maintenance-of-Way Work.—Now, with choice men well quartered comes the problem for the section foremen, roadmasters and maintenance officials of using the services of these men to the best advantage, so that every hour's work of every man is done where and in such a way as to return the best results to the property. Our maintenance-of-way work has too often been done in a haphazard manner, this, to a greater or less extent, because of the many interruptions that break into a day's work. Washouts, burnouts and derailments are emergencies that call for the immediate services of the section gang regardless of all plans for regular work. These, however, on the average well maintained railroads really consume but a small percentage of the time of the maintenance of way forces.

In order to get the best results from a certain expenditure on a section or on a roadmaster's division, the work should by systematized, and it should always be kept in mind that maintenance-of-way begins at the outside of the right of way fence, on one side of the right of way, and extends to the outside of the fence on the other side; and that right-of-way fences, surface ditches, policing of right of way, cutting of brush and grass, cleaning of cut ditches, including opening up of the same at the ends of cuts, keeping inlets and outlets of boxes and other waterways opened up, are as much a part of maintenance-of-way work as is tie renewals, ballasting or working with rail and track fastenings. All must be kept up if one is to do a good job of maintenance.

It is customary to replace or put splices on a broken rail at once when discovered. Next in importance should be the replacing of a broken tie, as soon as possible after it is discovered. This on the principle that if it is left in it not only makes bad riding track, but it tends to pull the track out of line and out of surface; and, with the heavy wheel loads of the present day, it throws too much of a shock on the ties on either side and is apt to break ties that would be good for one or two years' more service had it not been for this broken tie being left in the track three or four days when it should have been taken out when found, or the next day after it was found.

Ditching of cuts should be done systematically, and not left for "odd time" work. There is no work that pays for itself so promptly as ditching cuts; it saves surfacing the track through the cut at least once, and often twice, a year. A day should be set aside and section gangs required to ditch cuts either all of that day or a half of that day, and the foreman should be required in his weekly report to show the number of lineal feet of cuts ditched on one side during the week, and the location of the work. Repairs to right-of-way fences should be handled in the same manner.

There has been an idea on some railroads, especially with those where ballasting has been done only for a few years, that track ballasted with broken stone, gravel, slag, etc., should not be taken "out of face," but that the low spots should be raised and the line and surface maintained in that way. This is a mistake. All ballasted track should be taken out of surface once in every three or four years, and each section foreman should be required to take at least one-fourth of his track out of face each year, doing what he does continuously to a face. In this way it will be all taken out of face every four years.

In taking it out of face, the material on the shoulder should be screened and cleaned of dirt and used to make a 2-inch lift and new ballast should be furnished to fill in between the ties and for a new shoulder.

Another matter that has attracted my attention this season, particularly in the western country where we had so much wet weather and where we have such great crops, including a rank crop of weeds, and that is that our section foremen do not seem to realize the advantage of keeping this vegetation out of the track and ballast material. They are inclined to chase weak spots rather than to get after the vegetation. By digging out the grass and weeds it permits the sun and wind to dry out the ballast and embankment, and when dried out any work done on the track stays there; while if the track remains wet it goes down again after a few trains have passed over it. We want to remember always that the sun and the wind are good track men. They do not have to be transported to work—they furnish their own living quarters and they work from ten to sixteen hours a day, and do not have to be paid any overtime. We have all had it drilled into us, and know from our own experience, that good drainage is the first requisite for good track, and the drying out of the ballast and embankment by letting the sun and wind get to it is the same thing as drainage—one gets rid of the surface water, the other gets rid of the water that has soaked into the material.

Track bolts should be tightened at least twice a year, and both the bolts and the joints should be given a coating of crude oil at the same time. Some roads are oiling the rail below the head, including spikes, tie plates, joints and bolts, and they think it economical to do so, especially where they have much brine drip from refrigerator cars.

Maintenance of Way Budget as Means for Systematizing Work.—In order to do maintenance-of-way work systematically there should be a maintenance-of-way budget made up for each roadmaster's territory, subdivided into section foremen's territory. This budget should be divided:

First—Into the minimum organization that can keep up the track, not including tie renewals.

Second—The additional help required to do work that is required at certain seasons, such as mowing right of way and the tie renewal program.

Third—The additional help required to do work that would be of benefit and that would tend to cheapen future maintenance cost, such as widening of embankments and cutting of surface ditches.

Fourth—An amount to cover extraordinary expense due to weather conditions, wrecks, removal of snow, ice and sand, and other extraordinary expenses. This item should be based on average expenses for this class of work, say during the past five years, revised to fit present labor and material prices.

Under each of these headings the labor cost and material cost should be stated separately. This budget should be made up in detail as to linear feet of rail of differernt weights to be relaid; ties to be renewed, divided as to main tracks and sidings, cubic yards of ballast of each kind required, giving location where rail and ballast are to be inserted; number linear feet and location of cuts to ditch; number linear feet and location of surface ditches; number of linear feet and location of banks to be widened; number and kind of roadway signs to be renewed, etc., etc. With a budget of this kind carefully prepared, each section foreman has his year's work laid out for him and has something to work to.

Labor-saving Tools and Machinery.—With high-priced labor it becomes all the more necessary to keep tools in good repair, and, in the case of axes, adzes, scythes, shovels, and hoes, that they be kept sharp. A tool grinder should be kept on the section car at all times so that tools may be sharpened as soon as they become dulled.

There are several types of mowing machines made that can be attached to a motor car or handcar which will cut from 5 to 7 ft. outside the rail; there are disk weed cleaners that, in the case of gravel, burnt clay or cinder ballast, will clean the weeds from the shoulders. Tie tamping machines are in use on many roads, and experiments have been made in the use of a caterpillar tractor for mowing right of way, plowing fire guards and ditching cuts. With the class of men that we can get for the wages paid at this time we can operate any of these machines.

Much good work is being done at present in the use of the oxy-acetylene torch in repairing worn frogs and switches. Study should be made to see how any class of work can be done the cheapest, and if some mechanical arrangement will cheapen the work it should be used.

The heavy sections of rail now in general use make it necessary to use track-laying machines, and by their use the number of men necessary in a gang employed in relaying rail has been cut down fully one-half. In a similar way on ballast work, by the use of convertible side and center-dump cars, the amount of shoveling to be done in getting ballast to its proper location has been very much reduced.

The steam shovel and the ditching machine, together with a modern spreader, have reduced hand labor to a minimum in widening cuts and embankments. This is particularly true of the ditcher, the only trouble being that we, as a rule, have too few of them. There should be a steam ditcher on every operating division, and, in many places, on every roadmaster's division. They should be equipped with a 20-cu.-yd. dump car at each end of the ditcher, and, for all 'round purposes, should be fitted up with a clam shell and attachment for using the same. This permits of loading sand, gravel, cinders, etc.

Treated Ties Reduce Maintenance Expense.—Treated ties should be used to reduce maintenance expense. While one may not have the authority to get them on his particular road, he can, by calling attention to the saving, help to get the people on his road who do have the authority to thinking about the matter, and if they look into this feature they will not put off providing them very long.

Many roads have not adopted the treatment of ties because there are not some immediate economy and saving shown. Every official of a railroad should remember that he is only a link in the chain, and if he breaks and has to be taken out of the service some one else will take his place; but the railroad and its maintenance are a permanent thing and the life of an untreated tie is comparatively short; and when one has used treated ties for a period equal to the average life of the untreated tie, he will begin to reap the benefit of the investment.

Today the railroads that began using treated ties 10 years ago are reaping the benefit of the investment in big figures. They are averaging about 200 ties to the mile of all tracks, while the average number of ties used on a road where treatment has not been used is over 300 per mile of all tracks.

This means that a railroad that is using 2,000,000 treated ties per year would have to buy 3,000,000 ties had they not adopted tie treatment ten years before. This means $1,000,000, at the price that ties cost today, for the ties alone and much more than that—it means saving the cost of transportation, the cost of unloading and the cost of the insertion of a million ties; and the saving on insertion alone which at this time is from 32 to 40 ct. per tie, is a saving of from $320,000 to $400,000 of expense. There is yet another saving: one has disturbed his track in only two-thirds as many spots, and there is the saving of much retamping required later to get the track as solid as it was before the new tie was inserted.

Treated ties should be adzed and bored by adzing and boring machine before treating. This insures the seat for both rails being in the same plane and gives a full bearing for the tie plates, as tie plates should always be used on both treated and untreated soft wood ties, and on all treated hardwood ties.

Advantages of Rail Anchors.—Large sums are spent in squaring up ties where track has run, and this has to be done at least once a year. By the use of rail anchors, this can be avoided, and the labor of squaring up the ties and retamping them and of getting the track back in shape will be saved. They will save money if put on any track that is running, but they should always be applied on track when new rail is being laid, whether they were used before or not. What we must do to save money is to utilize any appliance that will hold the rail and ties where they belong, and not permit them to shift and move under train movements.

We began years ago when we had light rail and light power trying to prevent rail from creeping by slot-spiking at the joints. In the days of the fish plate a slot was cut in the base of the rail and a spike was driven there to hold the rail from running. Later, when the angle bar replaced the fish plate, we stopped slotting the rail and slotted the angle bar where it projected beyond the base of the rail. It was found that even this would not hold against creeping, and the rail anchor came into use.

We have been slow, however, with the perfecting of the rail anchor, to stop slot-spiking the joints, even though we all recognized that the joint was the weakest part of the track. Those who have stopped slot-spiking have seen its advantages, and it will not be many years, in my opinion, until it will be a thing of the past.

Owing to our joint troubles, there has been no end of patented rail joints, but within the last few years it has been recognized that what was most needed was improved material in the joints; and we now have the heat-treated, oil-quenched track joint and track bolt, and by using this class of material in joints and bolts, and a good spring washer, and by holding the rail with rail anchors, thus stopping the creeping action, the expense of keeping joints in good condition and the bolts tight, has been cut in two.

Steady Work Year 'Round for Section Gang.—It would be a great thing for all concerned, including the men employed on the section, if the work could be arranged so as to keep practically the same number of men on the section the year 'round. Four men the year 'round would be the same as two men six months, and six men the other six months. When we can provide steady work the year 'round for men they will make homes and be able to live much better and be more contented and dependable. Much work, such as relaying of rail, could be done in the winter with section gangs, by doubling them up, even to the extent of grouping four gangs; and with motor cars they could make the distance to and from the work and not lose much time.

We have been inclined to use large gangs, partly because the labor was so poor in quality that it took about three men to do two days' work, and partly because the labor was cheap. Under present conditions a careful study should be made of different classes of work where extra gangs are employed to see just how many men can be worked to the best advantage, and only that number of men, with a few extra men to insure full gangs at all times, should be employed.

Section Work Should Be Planned Ahead.—Section gangs that have several classes of work to do should plan to do that which is off the main track at the time in the day when the most trains are scheduled, and the main track work when there are the fewest trains to interrupt the work. They should have a list of the special work on their sections which it is planned to do, and should, when they send in their weekly reports, say how much of each class of that work they performed during the week, and should give an outline of the work they expect to do the coming week. This tends to make them plan ahead on their work and not go at it in a haphazard way.

Although many section foremen do plan their work, all are not gifted with the faculty to do so; but they can be trained to do a pretty good job at it if the roadmaster will take interest in their planning and discuss the matter with them when he goes over the section. The roadmaster also should revise his methods with the new order of things, so as to keep in closer touch with the methods employed by the foreman to get the best work.

The days of the roadmaster riding on the back of a passenger train and throwing off "butterflies" has about gone. While he should ride a passenger train over his territory in daylight about once a week, to keep in touch with the riding of the track, he should get over his territory the balance of the time on a motor car or on foot. A roadmaster should plan to walk over every foot of his track twice a year. He should plan to walk over one section each week, having the section foreman with him, if possible. He can do this in a half day, and he should make a written record of the things that he sees that requires attention; and when he gets in he should write a letter to the section foreman, calling attention to them, so that the foreman will have a record of the matters, and when the roadmaster walks that section six months later he should have this record with him and see if the things he called attention to have been corrected.

Prizes for Best-kept Sections.—There should be a continual campaign on to keep the right of way clean, and all scrap should be picked up and shipped regularly to the storekeeper. The custom of giving prizes for the greatest improvement and best-kept section is of great value (much more than the cost) in stimulating every one to try and keep things neat, and to maintain good track and right of way.

I was recently over a railroad which is through a desert country, where prizes are offered for the best and prettiest-kept section house yard, also for the neatest appearance of the interior of the section houses, and it was surprising what beauty spots some of the section house yards were, with nice trees and shrubs and both vegetable and flower gardens. The engineer of maintenance, whom I know, is making a campaign among section foremen to get them to have a good vegetable garden, with the result that nearly every section house has a good garden, which helps to give the family a better living and to reduce the present high cost of living.

The 8-hour day has reflected a greater hardship on railroad maintenance of way than probably any other class of work, for the reason that section gang's work is scattered out from 4 to 10 or 12 miles, and the men go to and from the work on the company's time. The result is that where hand cars are used the effective time on track is only 6½ hours, and even with motor cars it is only about 7 hours per day. This gives the men a long period of daylight when they are not working on the railroad, and they should be encouraged to put in a portion of this time during the summer months in making and maintaining a garden, and should also be encouraged to keep hens and a pig, and, when possible, a cow.

This will tend to reduce their cost of living and it will, by the additional production, help in a small way to offset the great economic loss that has been caused by the general introduction of the 8-hour day, which has curtailed production and thereby increased the cost of living in this country from 20 to 25 per cent, and this does not take into account the increased amount that a man in a town or city will spend with two hours more of loafing time on his hands. Every man whom we can encourage to have a garden, to saw up ties into firewood, or anything else that will increase production, will be helping to decrease this great loss and the consequent increase in the cost of living.

We can improve our methods and create a better feeling among the section foremen if the roadmaster will get them all together at some central point once or twice a year and have a general discussion of section work. A program should be made up, giving a list of classes of work, and each in turn should be discussed, and every man should be obliged to get up and say something about it. The section foremen should also be encouraged to talk such matters over with the men in their gang.

Encouraging Employes to Save Money.—There is bound to be an adjustment of wages downward when things get settled in this country. Every one should try to save something out of the present high wages. There is no class of people who find it harder to save money than railroad employes, owing to their being transferred from place to place, and thus being discouraged from purchasing real estate.

Building and loan associations are today regulated by the states, the same as banks, and are safe places to invest money, and they have the advantage of taking monthly payments. Building and loan stock matures usually in from 100 months to 10 years, and the time passes very quickly.

The officials of the Santa Fe road formed such an association about 17 years ago, at Pueblo, Colo., to encourage employes to save money. We paid 60 ct. per month per share. I took ten shares, costing me $6 per month, and when it matured and I got a thousand dollars I hardly knew where it came from, it had taken so little effort to save it.

I want to suggest that you talk to your section foremen about saving some of their money in this way, and they may induce some of the men to do the same thing, and it would not be a bad plan for each of you to set them the example by picking out some local building and loan association and taking out ten shares of stock. If they find you are doing this they will be more apt to try it. The man who is saving money is more apt to want to work steadily, and he is also more apt to be saving for the company that he works for.

Now then, let us take off our coats and get down into the collar and pull for more and better work; more and better living quarters; more and better acquaintance with our men and our work, and more and better economy, both in our own expenditures and in those for the railroad company. Let us try to save some of our surplus earnings in these flush times, and let us further bear in mind that the days of rough language and the pick handle are gone and that we should treat every one under us fairly, requiring good, steady work, not only with their hands and feet, but with their heads; but be square with them, so that they may, while working hard, keep their self-respect and have respect for us.

Cutting Weeds on Railway Right of Way With Farm Mowing Machine

Mr. Edwin Main, Chief Engineer of the Rockford & Interurban Ry., describes in the Electric Railway Journal an outfit for mowing weeds used on his railway. It is a long, slow job to mow miles of right-of-way by hand, and to more expeditiously handle such a situation the Rockford & Interurban Railway has drafted into service a standard farm mowing machine and substituted a single-truck motor car for the customary pair of horses.

An Emerson Brantingham standard 7-ft. mower is used with the wheels replaced by city electric car wheels of the same diameter. In order to obtain standard gage it was also necessary to install a new axle. The sickle bar was a little too long to clear the poles of the two-pole system so 6 in., including the shoe, was cut off. On portions of the line single-pole construction is used and here it is still necessary to raise the sickle bar at each pole.

The tongue of the mower acts as a safety valve and is therefore constructed of a grade of oak which will break should the sickle bar hit a stump or pole. The tongue is made of 4-in. x 4-in. oak about 7 ft. long and extra tongues are carried for emergency use.

The mower is coupled behind a single-truck two-motor car with plenty of resistance temporarily built into the interior of the car so that the equipment may be operated on two or three points. This gives a speed of about 5 m.p.h. The crew is composed of three men, including a motorman, a mower operator and a man to raise the sickle when necessary.

On the divisions equipped with double-pole construction, 12 miles per day is the average mowed. About 7 miles per day is accomplished on the divisions equipped with single-pole construction.

Convention of National Drainage Congress.—The National Drainage Congress, an association of interests throughout the nation directly or indirectly concerned in the drainage, reclamation and development of swamp and overflowed lands, will hold its annual convention in St. Louis on Nov. 11th, 12th and 13th, with headquarters at the Planters Hotel.

Results of Improved Inspection in Steel Rail Manufacture

In a paper presented at the Chicago meeting of the American Institute of Mining and Metallurgical Engineers in September, Mr. Robert W. Hunt, the well known rail expert, describes the system of special inspection inaugurated by him in 1912 and used in behalf of several of the large railway companies, and gives the general results coming from this improved and greatly detailed inspection.

This "Special Inspection" consists in placing inspectors in all the departments of the steel works, beginning at the open-hearth furnaces or Bessemer converters, at the soaking pits and the blooming mill, the rail mill, the drop-testing machines, the hot beds, drilling and straightening departments, and, finally, the inspection of the finished rails. These men are placed at each of these several departments day and night, their duties being to observe carefully all the details taking place; and if there should be any deviation from the provisions of the specifications under which the rails were purchased, or deviations from the accepted practice of the mills, or abnormal conditions of any kind, to make note of the same; and while not at liberty to interfere directly with the workmen, to call the attention of the foreman of the particular department in which the occurrence is taking place to what is happening, and also to pass a written report to the inspector stationed in the next succeeding department, and so on to the finished-rail inspectors. The chief inspector is also required to give a written report of unsatisfactory conditions to the superintendent of the mill, so that there may be an absolute record of what has happened to each heat of steel made on either turn, be it day or night, and as the rails are stamped with their heat numbers, and location in the ingots from which they were rolled, the mill management will possess an individual history of each rail, with the possible identification of the individual workmen who were in control of the manipulation of the rail from beginning to end.

Moreover, a comprehensive report is rendered to the proper official of the railway company for which the rails are manufactured, resulting in the archives of that railroad possessing a detailed history of the making of the rails. Hence, should a rail fail in service, it will be possible to not only have cognizance of all the details of its manufacture, but the makers will be able to determine the workmen who participated in that manufacture. As can be appreciated, this leads to a personal responsibility being attached to every rail. It must be remembered that the workmen at the mills are paid by the ton, hence they are naturally desirous of producing as large an output as possible, and under the ordinary system of inspection, as soon as the rail left the works, all individual connection with it vanished, or, at best, any process of personal connection was extremely difficult and uncertain.

The result of this special system of inspection has been most satisfactory to both the manufacturers and the purchasers, and it receives the approbation of the workmen themselves, as each man knows that if he properly performs his duties, he is protected against the danger of being held responsible for the acts of a less careful operative, while the mill management has given it, without cost, a thorough system of supervision. That it has proved satisfactory to the railway companies, who have been employing it, is best evidenced by the following, gathered from the records of the American Railway Engineering Association.

The statistics covering open-hearth steel rails give the failures that have occurred in 5 years, ending Oct. 31, 1917, on 37,862 miles of track. Forty-five per cent of this mileage comprised rails rolled under special inspection, and therefore 55 per cent was made under other conditions.

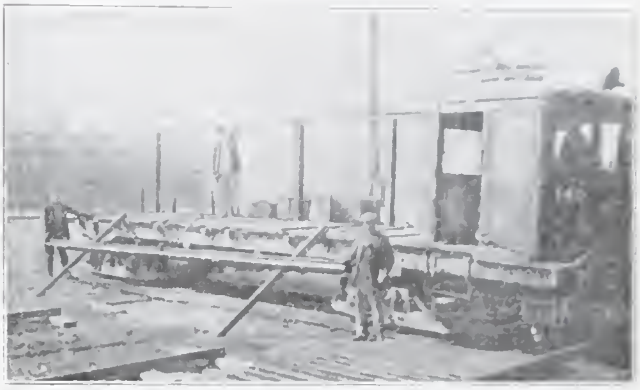
The total number of failures per hundred track miles on all the mileage reported was 31.1, while the number of failures per hundred track miles on the rails covered by special inspection was 26.6, and the number of failures per hundred track miles of those not covered by special inspection was 34.8. Thus, there was 30 per cent in favor of specially-inspected rails.

Building Materials Congress in Norway.—The Norwegian Association for Dwelling Improvements is planning to hold a building material congress, probably in January, 1920, at Christiania.

Drag-Line Car for Handling Track Materials

The United Railways of St. Louis has recently equipped a flat car so that rails, switches, frogs, and other track material may be handled with a minimum of labor. The car is 40 ft long and has embedded in the floor as skids, 60 lb 4 in T-rails. The equipment consists of a drag line operated from an 8 in. by 11 in. drum driven by an old Westinghouse 30 h p railway motor suspended from the car floor on the left side just ahead of the forward truck. It is connected by sprocket and chain to a drum mounted in the cab.

A rack has been built along the left hand side of the car. There are four 6-in. I-beam uprights extending 6 ft above the floor and braced at the bottom. There is one lighter I beam upright just back of the cab which is braced against the cab. The top longitudinal member is a 6-in. channel with a wood filler. The drag line passes from the pulley in the cab through a block which may be fastened at any one of the uprights.



Drag-Line Car Used at St. Louis for Handling Track Materials.

The tongs used with the drag line were designed especially for the purpose, for they are always pulling at such an angle that the ordinary tongs would catch on the edge of the car floor. Sections of 4-in. T-rail are used as skids and these hook into angle braces on the side of the car. Two skids are used for rails, but for other pieces of special work three or four may be used.

The Electric Railway Journal, from which the above is taken, states that formerly 10 to 14 men were used in a crew to handle rails and special work. With the equipment described above it is a very simple matter to handle practically anything of this nature with three men and a motorman. Thus a great saving in labor expense is realized and a negligible amount of heavy work is required of the men.

This equipment for handling track material was originally designed because of the impossibility of obtaining sufficient labor.

Herbert Hoover: An Appreciation.—At the dinner given Sept. 16 by the American Institute of Mining and Metallurgical Engineers in honor of Herbert Hoover, loose leaf pages were provided at each table for the signatures of members and guests. These pages were afterward bound together in book form, together with an illuminated appreciation, and presented to Mr. Hoover. The appreciation follows: The members and guests of the American Institute of Mining and Metallurgical Engineers, assembled to commemorate his return home, extend the welcome due an eminent American citizen, a successful engineer, a genius of constructive administration, a practical economist, a statesman of world vision. In him they honor an idealist who was able to vitalize the altruism of America and save from hunger and anarchy vast areas of Europe where millions of men, women and children in a score of languages lift their voices to call him blessed. He is loved and honored for his gift of leadership and inspiration which called many thousands of volunteers to his aid in the great tasks he undertook and accomplished. Realizing that no gift of gold or precious stones could convey the deep feeling of appreciation we wish to express, we simply subscribe our names as fellow engineers, co-workers and admiring friends.

Tunnelling Machines in Sewer Excavation

Tunnelling machines are being used in constructing a 12,000 ft. section of the $9,000,000 sewer project now under way at Detroit, Mich. This section consists of 3-ring brick and concrete sewer 7 ft. to 9 ft. in diameter. It is being built through a tough and tight blue clay. The machine consists essentially of a revolving cutting head driven by an electric motor. This cutting head is fitted with knives backed with springs to make them more flexible. A screw conveyor at the center of the cutting head connects with two continuous belt conveyors. The machines are provided with continuous trend traction. When the machine is in operation the earth is shoved from the face of the head, guided into the screw conveyor and thence onto the belt conveyor, where it falls into muck buckets. The following particulars regarding the operation of the machines are taken from Successful Methods:

At intervals of about 1,000 ft. shafts 10 by 12 ft. in size are sunk to the depth of the proposed sewer. This depth varies from 20 to 40 ft. The shafts are lined and thoroughly braced. At the foot of these shafts headings are started and enlarged until sufficient space is provided to permit the erection of tunnel machines.

Two lines of 14-in. gage track are provided, upon which small cars run, each one loaded with two muck buckets. Loaded cars leave on one track and the empties return on the other. These cars are pushed by men to the foot of the shaft where chains are hooked on and they are hauled to the surface. The muck buckets are lifted by a 20 hp. hoist using a ¾-in. cable over a 12-in. pulley until clear of the receiving platform, a 5-ft. gage car is run under them and they are lowered to the car. This car is pushed out on the dumping platform by hand and the buckets are tilted over dump boards into wagons waiting to receive the spoil. The spoil is hauled off and used for filling.

The average progress made by two tunnel machines over a period of 29 days of 8 hours each was 16 ft. for one machine and 15 ft. for another. These machines were operating in different headings, but muck from them was hauled to the same shaft.

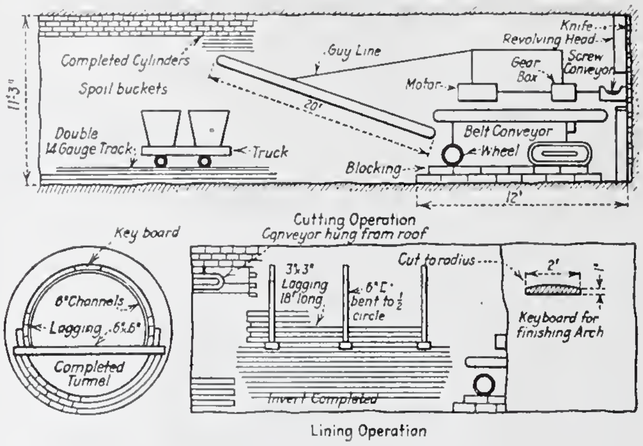
At the end of 8 hours' operation the tunnel machine is stopped and the workmen spend an hour cleaning up and getting ready for the bricklayers. During the night the tunnel cut in the preceding shift is completed by lining with brick or concrete. In building a brick lining 5 bricklayers take care of the work of 2 machines. In making the tunnel lining 5 men lay the invert following one machine and set the steel templates. When this is done, 3 of the men go to the other end of the tunnel and begin to lay the invert, following the other machine, while the other 2 men finish the arch. Lagging, 3 by 3 in. in size, is placed as the cylinder is completed. A whole 18-ft. section is completed on both sides except for a 2 ft. space at the top. Key boards are inserted in this space, supported by the lagging on either side, and the whole key, 18 ft. long, is built at one time. While 2 men are finishing the key the other men go back in the other end of the tunnel and assist in the completion of the arch, following the other machine. Mortar is mixed at the surface in a small concrete mixer and delivered through a 6-in. pipe chute to the bottom of the shaft.

Cutting Head of Tunneling Machine.

The following force is required to operate the machines, drive the tunnel and care for the spoil:

Night.	Day.
5 bricklayers.	6 tunnelmen.
14 laborers.	8 laborers below ground.
1 foreman.	8 laborers on top.
2 inspectors.	2 engineers.
1 hoist man.	1 inspector.
	1 foreman.
	7 teams.

This force operates 2 machines. Three men are used to operate each machine and teams are used only in the daytime, as the machine does not operate at night.



Under Ground Plant Layout.

The contractors on the work are Jaynes & Affeld, of Detroit, Mich., with Fred Jaynes as superintendent. John A. Wagner is city inspector, acting for C. W. Hubbell, city engineer of Detroit.

Why the Unions' Railroad Plan Is Doomed to Failure

(Editorial from the Public Ledger, Philadelphia.)

The fallacy in the whole plan of the "Big Four" brotherhoods lies in the assumption that a great railroad system can be run and expanded without great constructive genius, and that great constructive genius will work without adequate incentive.

It was the brain of J. J. Hill that conceived and built the Great Northern system and developed the Northwest. The opportunity was there, but Hill saw it and had the nerve to take risks in order to prove that his faith in the future of the district was well founded.

There are just as efficient conductors and engineers and firemen working on the road as when he laid the first rails, but they could not have built up the system.

There is in every city a score of large business enterprises which existed first in the brain of one man. The employes whom he has called to his assistance could not have developed the business, though some of them think that they should control it and tell the directing brain what he should do.

And there is in every city one or more great enterprises built up by the genius of a single man which have gone to ruin when that man died.

Men of ordinary ability are for sale; but the constructive genius never sells himself. He commands the services of others and builds on the foundations which are embedded in his own will and in his own determination to put the thing across.

The world is full of wrecks of big enterprises, the inheritors of which, whether they were the heirs of the founder or the subordinates who took it over at his death, were too little to carry on.

There may be railroad geniuses in the brotherhoods, but they are not in sight, and the chances are all against the success of their plan, even if it were advisable for other reasons.

Drilling and Blasting Methods in Sinking 1,830 Ft. Mining Shaft

High drilling efficiency and rapid progress were obtained in sinking a shaft at the Pabst mine of the Oliver Iron Mining Co., Ironwood, Mich. The work was started on June 20, 1917, and in March, 1919, the 1,830 ft. shaft was completed. During this period all steel sets, bearers, dividers, concrete lath and skip runners were placed, and, in addition, all stations were cut, pockets built, and cages and buckets put in operation. The progress made in the sinking and equipping the shaft is thought to establish a record for the district. The following particulars regarding the work are taken from an article by A. J. Wagner in the Engineering and Mining Journal.

When the work was started it was decided to make each part of the job as complete as possible while sinking proceeded, for it was believed that in the long run time would be saved by so doing, rather than to push the sinking and then complete the steel work and equipment later.

The shaft is vertical, with outside dimensions of 18 ft. 4 in. x 11 ft. 4 in., and is divided into one cage compartment 10 ft. x 5 ft. 8 in., two skip compartments, each 5 ft. x 6 ft.; one pipe compartment, 3 ft. 8 in. x 5 ft., and one ladder compartment, 3 ft. 8 in. x 5 ft.

The long axis of the shaft was placed perpendicularly to the strike of the formation, taking the natural ground slippage on the end of the shaft. This is the first shaft so situated on the Gogebic Range. In sinking, the first 9 ft. was overburden, and this was followed by slate that continued to a depth of 725 ft. At this point granite was cut, and granite with dikes continues to the bottom of the shaft 1,830 ft. from surface.

The sinking crew consisted of eight miners and one shift boss on each of three 8-hour shifts, making a total of 27 men. These men performed all the work in the shaft, such as drilling, charging, blasting, mucking and timbering.

The drill equipment at the beginning consisted of 12 Butterfly Jackhamers, Type BCR430, equipped with ⅞-in. hollow hexagon steel and four-point bits. These were used in the slates to a depth of 589 ft., at which point harder ground required a stronger and heavier drill. Twelve Jackhamer sinkers, Type DDRW13, then replaced the Butterfly machines. The factor of primary importance in speed of sinking is to break the ground, and the remarkable accomplishment of the drilling machines used in the shaft made possible the fast record. A 9-ft. sink the full size of the shaft was drilled, charged and blasted in 8 hours, the actual drilling of the full round, totaling 442 ft., requiring from 5 to 6 hours. The drilling time from start to finish of a 9-ft. hole in granite averaged 30 minutes.

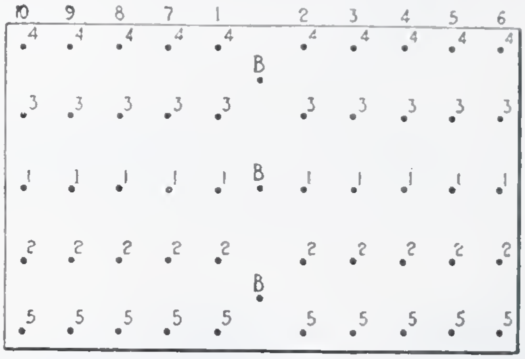
When material was removed from the shaft at the end of each drilling period the eight used drill machines were sent to the shop with the drill steel, and each machine was opened, inspected, cleaned and lubricated before it was returned to the shaft. The result was an extremely low maintenance cost and a uniformly high drilling efficiency. The warehouse record shows a maintenance cost for the year 1918 to have been only $2.51 per month per machine. As each machine drilled 6,000 lin. ft. in hard ground, the cost of maintenance was $.005 per foot drilled. As convincing proof of the value of high-grade inspection and careful lubrication, it may be stated that upon completion of the shaft the drills were mounted and placed in service on the main level drift and on sinking work at other mines.

As ⅞-in. hollow hexagon steel was in stock, this size was used in the sinkers, although they were designed to use 1-in. steel. The drill steel was made up with 2 ft. starters, and the last drill was 11 ft. long. The bits were standard four-point with a 90° cutting edge and 5° and 14° taper. The gage of starters was 2⅓ in., with ⅛-in. change in gage and 18-in. change in length. The steel was machine sharpened at the collar of the shaft in a No. 5 Leyner sharpener. No difficulty was encountered with steel breakage or inability to make the drills "follow."

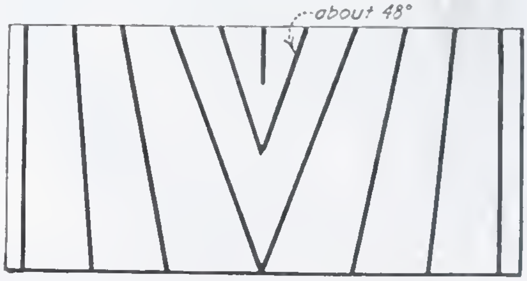
Air for the machines was supplied by a 6-in. air pipe provided with a standard manifold. A specially designed header was discarded early in the work, as its use was found to be troublesome.

The cut was drilled so as to remove, when blasted, a "V" at the center of the shaft, and consisted of five rows of five holes each in each half of the shaft, with three extra holes drilled straight down across the center of the shaft. An accompanying diagram shows a plan and section of the distribution of the holes.

In the diagram 53 holes are shown. In slate 50 holes were drilled, the three center holes marked "B" being omitted. The numbers on the holes refer to the order of blasting. The three holes marked "B" were shot by means of a battery to relieve the cut. The holes numbered 1 were fired first; 2, second, and the others in rotation, and the row numbered 1 was fired first; row 2, second, and succeeding rows in like order, the rows up to 6 being shot and then this part mucked out. Rows 7, 8, 9 and 10 were next fired in sequence, completing the cut. By firing in this order a wiggle or staggered effect was obtained, throwing the dirt from side to side, breaking any big blocks loosened, saving the shaft timber from damage, and putting the entire charge off as it was timed to go, without prematurely exploding other holes. Delayed fuses were used and the holes charged with eight sticks of 80 per cent Red Cross gelatine, the detonator being placed in the fourth stick from the bottom. This arrangement is contrary to the rule for placing the detonator, but owing to the fact that the holes are close together, the collar often breaks prematurely and tears out the detonators that have not been exploded. When this happens some of the holes do not explode and too much burden is placed on other holes.



Plan
(Drilling and Blasting)



Vertical Section
Order Followed in Blasting Machine Drilled Rounds.

No cut failed to be pulled clean, and not one steel shaft set was bent, although the sets were kept within 15 to 20 ft. of the bottom. The blasts were timed so close together that the effect was to blend the concussion in one slow rattling blast.

After blasting, the muck was hoisted in two 20 cu. ft. sinking buckets, provided with special guides. At the trestle landing the buckets were dumped while hanging straight on the cable, the rock falling on an inclined shaft cover. This sloping cover was hinged, provided with high sides that formed a chute, and was swung in and out of position by means of air-operated cylinders. The complete cycle of work in sinking was as follows:

TIME REQUIRED PER CYCLE OF WORK IN SINKING PABST "H" SHAFT

Operation	Time hours
Take down material and drill entire cut	6.0
Charge holes (first blast)	1.0
Remove material and blast	1.0
Blow smoke	1.5
Muck first blast	8.0
Charge second blast and fire	0.5
Blow smoke	1.5
Muck second blast	6.0
Hoisting water with bucket, per day	1.5

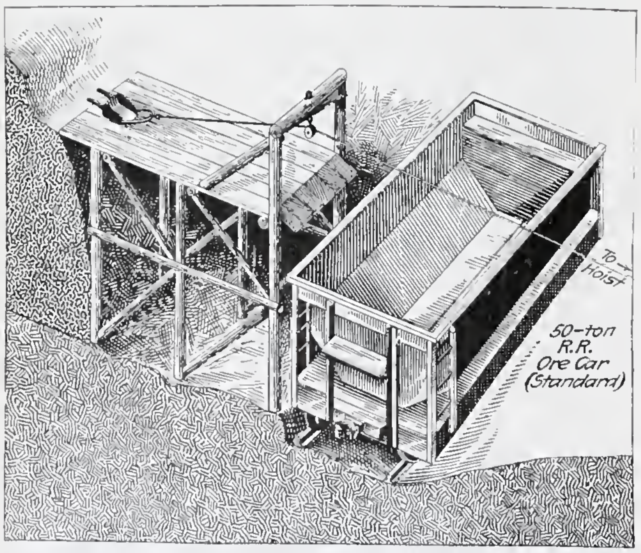
Timbering, per set	5.5
Cutting and blasting hitches	8.0
Installing bearers	3.0

The shaft sets extending through the encountered slates are made of 8-in., 34-lb., "H"-section steel and 6-in., 22.8-lb., "H"-section throughout the remainder of the shaft. They were spaced at 5 ft. centers. Dividers were of steel. Bearers were placed every 100 ft. in depth, four bearers to a set, one under each end plate and one under each cross divider. The bearers are 12 in., 31.5-lb., I-beams, 17 ft. long, cut in the middle for purpose of installing and spliced after being placed. Hitches 3½ ft. deep were cut to fit the steel, and this was done by drilling one side and the bottom of each hitch, the holes being placed side by side, each hitch requiring nine holes. Iron wedges secure the bearers.

The lath or lining consisted of pre-cast concrete slabs 8 in., 10 in., and 12 in. wide by 4 ft. 10 in. long and 3 in. thick in the slates and 2 in. thick in the granite. The slabs were designed with one vertical edge on each face, beveled to permit easy installation, and held in place by angles riveted to the "H" sections. The lath was wedged from the rear with cedar blocking. Men and material were handled on a cage and dirt was hoisted by buckets, the three hoisting compartments being used.

Loading Cars With a Drag Scraper

A device which was used in loading a small iron-ore stock pile on one of the Minnesota ranges is illustrated in the accompanying sketch. Little ore was stocked in the winter, and the entire tonnage contained in the mine was removed during the following shipping season. The ore hoisted in the summer was dumped from the skip into a loading pocket and thence drawn off into standard railroad cars. The stockpile tonnage was small, amounting to only a few thousand tons, and the expense of installing a steam shovel for its removal was considered unnecessary. The method employed is described as follows in the Engineering and Mining Journal:



Method of Loading Cars with Scraper.

A small loading platform of 8-in. diameter round posts and 2-in. plank was constructed near the track, which was continued some distance beyond the shaft to permit the spotting of coal cars. The two uprights on the track side were extended above the top of the platform and connected so that they formed a frame, from the center of which was suspended a small block pulley. The platform was about three feet above the top of the cars, but sloped on the outer edge so that the ore would run into the cars. An ordinary road scraper was used, fastened to ½-in. cable passed through the pulley and attached to a small hoist, which was furnished with steam from the boiler house. The far side of the stockpile was removed first. The operation of the scraper required two men. When about half of the pile was moved, the grade became too steep, and it was necessary to provide a small incline to secure the remainder of the ore. Alll material, with the exception of the scraper and the pulley, was in stock at the mine, and the entire rigging was built at slight expense.

Accident Prevention in Construction a Source of Profit*

By F. L. HURLBUTT,
Of the Safety Section of E. I. du Pont de Nemours & Co.

The writer proposes to treat this subject from the data and experience of the construction forces of the Du Pont Co. In the Du Pont Company safety on construction work is divided into two distinct branches: home office and field work, each of which is in such close contact with the other as to benefit by the other's experience and ideas.

Work in the Home Office.—The work of the home office branch covers co-operation with the design division of the engineering department in the initial stages of all contemplated construction work and later with the drafting room forces when actual drawings are being prepared. Close contact with the design division is absolutely necessary in order to get preliminary data on manufacturing processes involved in which there may be industrial poisoning hazards, the necessity for ventilating systems, the possibility of explosive hazards necessitating proper barricading and separation of buildings and quick escapes for operatives; in short, all such important points as require special investigation and decision before judicious recommendations can be made to the drafting room forces. By conference with members of the design division all these points are thrashed out and decisions reached, so that no delay is experienced when the work has gotten on the drafting boards. Too great stress can not be laid on the importance of carefully reviewing all projects for safety in the design or formulative stage. This is particularly true when construction work is to be done for such highly specialized industries as the chemical, steel and explosives branches. At this stage the incorporation of the necessary safety and health features can be included at about one-third the cost of doing them than as additional work after the job is completed. Furthermore, they can never be done as satisfactorily or made as effective when done afterwards due to the layout of apparatus, equipment, stairs and elevators within the buildings. One member of the safety office is detailed to the drafting room to check drawings for safety and to advise the draftsmen on the application of the Safety Standards where complicated situations arise or where unusual conditions make deviation from the standards necessary.

The review of the contemplated work and the check in the drafting room are in the main to cover structural plans and layouts of equipment for safety and not the mere noting of locations for safety devices which is primarily a field job. To insure the inclusion of this work in the finished job a formal note is placed on every drawing stating that all equipment is to be guarded in accordance with the standards, thereby giving the field engineer authority to carry out this work and at the same time freeing the drawings from a mass of notes and sketches of machine guards.

The actual installation of safeguards and safety devices by the field engineering forces in the case of large undertakings is supervised by the Safety Engineer assigned to that particular construction job and in the case of small jobs by trips by members of the home safety office.

Actual Field Safety Work.—On all projects requiring a field force of 500 men and upwards it has been found not only desirable but essential to include on the engineering staff a safety department, the personnel of which must be varied as conditions dictate, from a single man to as many as eight men devoting their full time to safety, supplemented, if necessary, by an injury clerk and accident investigators with adequate clerical and stenographic help to maintain full and accurate records of all injuries. Such a department as this last may seem unnecessarily large, but I want to assure you that on our two largest construction jobs where such departments were maintained, the members were about the busiest individuals on the ground. Not only must physical inspections be made of the work under erection, the unloading and piling of vast quantities of materials, inspections made of railways, cranes, tool rooms and what not, but educational safety for the field forces must be carried out, accidents investigated in order that preventive measures may be applied and full data surrounding the accident secured. Thorough accident investigation has proven of enormous value and is one of the most important duties of all our safety departments. As in all professions, an accurate determination of causation will generally bring to light the proper remedy.

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*From a paper presented Oct. 2 at the Eighth Annual Safety Congress of the National Safety Council.

How Safety Work Has Justified Itself and Dividends It Has Returned.—In the early part of 1918 the company undertook its largest construction project, namely, the complete design and erection of a smokeless powder plant for the United States Government. Some idea of the magnitude of the undertaking may be gained from the fact that an average working force of 25,000 men was maintained. Like all war projects this was a rush job and had to be carried out in the face of the very serious labor shortage and consequent high labor turnover that existed at that time.

At the outset the question arose as to how safety and injury work should be handled. Two courses presented themselves. First, to carry liability insurance with an outside company and waive any further responsibility in the matter, or second to carry our own insurance and organize a complete safety department on accident prevention work. The former scheme might have been adopted in view of the difficulty of getting good safety men on short notice at that time, but the excellent results attained on our other big jobs completed prior to this country going to war justified our pursuing the latter course. As a result a safety department consisting of a safety engineer, an assistant safety engineer, seven inspectors, a personal injury clerk and assistant, two accident investigators and five stenographers was organized. As in the case of all successful safety work the resident engineer gave the department his unqualified support and "put safety on the map" from the start by stating his stand at the weekly staff meetings and seeing to it that his division engineers were carrying out their share of the responsibility of accident prevention. This he was able to do through the daily accident reports forwarded him by the safety department. The policy of carrying out safety work through the organization rather than allowing the safety department to do it all was the basic principle followed. Meetings of the division engineers and their assistants were always attended by a member of the safety department who showed the results accomplished and brought up points to be rectified. Again, foremen's meetings were held in the various divisions at which the division engineers put the proposition of safe working conditions for the men and accident prevention squarely up to the foreman. And right here let me digress for a moment to emphasize the importance of the foreman in any accident prevention work, no matter whether it is an operating or construction job. Only when your foremen are whole souledly behind the safety movement which you are pushing will you effect permanent accident reduction. These men are the most important factors in your campaign and the bulk of your efforts should be directed towards winning them to your ideas. You look to them for the desired speed of the work and for its quality; why then should you not look to them for the safety of the workmen entrusted to them? But to return to our subject. Without going into too great detail on the methods followed by the safety department, suffice it to say that the department, in addition to the educational work carried on through engineers' and foremen's meetings made daily physical inspections of the work, posted thousands of bulletins and superintended the installation of over 3,500 safeguards for mechanical equipment.

The injury department, through its investigators, investigated every accident and submitted complete reports on them. The result was that the number of court cases resulting from injury was very, very small. This is a phase of safety work on construction in non-compensation states which, if carried out effectively, pays a handsome return. If all accidents are reported and immediately investigated and the injured brought to the hospital for treatment, the likelihood of the cases being taken to court are greatly minimized. It only takes about one or two court cases where a verdict is rendered in favor of the plaintiff, to pay the entire cost of a safety department on a fair sized job.

On March 23rd, shortly after the start of construction activity, the safety engineer arrived on the job and began building up his organization which had by the latter part of April assumed working proportions. By this time the department had started an effective, organized safety campaign with the following results: During March and April, the period of organization for the department, the "Lost Time Rate" expressed in days had steadily increased until it stood at 2.27 days lost per man per year. By May 31st, one month after safety activities had been prosecuted in earnest, the figure was reduced to 1.28, the next month saw it lowered to .744, the following month it stood still, but the next month saw a further reduction to .684, then came a drop to .351. In the next thirty days we find the only upward trend in our curve, when the figure went up from .351 to .411, really an excellent figure in itself. But again, with the last month of activity, we find the downward tendency resumed with the result that the lowest figurest of all was attained, namely, .216. Reflect for a moment what this means. In the seven months of the safety department's activities the lost time rate had been reduced from 2.27 to .216, a 90 per cent reduction, which is truly a remarkable record, when you consider that it was made in the face of a very high labor turnover and with a working force almost entirely new to the company. The total frequency calculated on the annual basis after the federal practice was 58.9. The fatality frequency rate calculated on the same basis was 1.0.

When the gigantic project was first conceived a rate was quoted the company for carrying liability insurance on all the construction employes. Using this rate, the cost of insurance against injuries, both fatal and non-fatal, to the company would have been $452,752, as against the actual cost of $66,101, a saving of $386,651. Deduct from this the cost of maintaining the safety department, $50,000, and we have a net saving of $336,651.

On the construction of a large shell loading plant where similar safety efforts were carried out by the company, though not on quite as large a scale, equally impressive figures are available. Here the success of the safety work resulted in the actual cost of injuries being but $5,733, as against a figure of $103,545, had we chosen to carry liability insurance with an outside firm. This gives a saving of $97,812, from which the cost of maintaining the safety department, $10,500, must be deducted, giving a net saving of $87,312. Here the total frequency rate was 47.8 and the fatality frequency rate was zero. The figures quoted are meant in no way to deprecate the practice of carrying liability insurance. Most assuredly such a policy is a meritorious one on small and good size contracts, but when an undertaking assumes such gigantic proportions as did the construction of the Government powder plant just mentioned, one is faced with a proposition which could never be as satisfactorily met by any outside agency as by a department which is a part of and coordinating with the contractor's own organization.

To digress a moment from monetary savings, let me relate an interesting accident prevention story that occurred in connection with the powder plant construction and one which carried good evidence of whether real safety work pays on construction. In May, 1916, during a temporary lapse in construction activities in his particular line, one of our best construction engineers was made safety engineer on one of our largest plants, where an average operating force of 12,000 men and a construction force of 700 was then being maintained. For two years he acted in this capacity and became a real convert to the safety cause. When construction work was started on the Government powder plant, this individual was made a division engineer in charge of the "Miscellaneous Division," which comprised a force of from 2,500-2,800 men. This was exactly the opening he wanted—an opportunity to practice as an engineer on construction what he for two years had been preaching to other construction engineers. Were his preachings vindicated? His record will answer that question. From March 16, 1918, to Sept. 1, 1918, his working force of 2,500-2,800 men had but one major injury.

Accident Prevention Work and Safety Campaign on Recent Construction.—Such examples as I have cited may seem to be of such an unusual character and the work carried on under such abnormal conditions that it is not fair to use the results obtained therefrom in arriving at a decision whether safety work pays on construction. To allay any such doubts, let me tell you of the accident prevention work and safety campaign, with the excellent results attained, which has been carried on during our construction of a large chemical plant these past eight months.

This construction was under the direction of a resident engineer with ten assistant engineers on his staff. The average number of full time workers employed, using the Federal basis of calculation, for the first eight months of the year was 692. Directly under the resident engineer was a field safety engineer, with an assistant and one man acting as an accident investigator, clerk and stenographer. In outlining the safety campaign it was decided to try two schemes, both of which were new to us on construction work. These schemes differed only in application, the basic thought behind both being to hold the foremen and general foremen responsible for carrying on the safety work, with the safety department functioning in a stimulating and advisory capacity to the engineering organization and foremen.

The construction was divided into two divisions which, for convenience in explanation, we shall designate as "A" and "B."

In Division "A" there were scheduled Foremen's Safety Meetings twice a month for the varied crafts, each meeting being presided over by the general foreman of that particular craft and attained by the Safety Engineer solely in advisory capacity. This division had a safety committee made up of its seven general foremen, one of whom was appointed permanent chairman and another secretary by the division engineer. The personnel of the committee was not rotated. Every other Saturday afternoon, from one until three o'clock, they made a safety inspection of the construction work in their division and submitted a written report of their findings to the division engineer, with a copy to the safety engineer.

In Division "B" there were scheduled weekly safety meetings of the foremen and general foremen of all crafts in this division, presided over by one of their own number and having a secretary appointed by the division engineer. This division had three safety committees of three men each, each man serving six weeks, with one man being dropped every two weeks and a new member appointed by the committee chairman, who was elected by ballot. These committees made inspections every two weeks of the construction work in this division and submitted a written report of their findings to the division engineer.

After the two schemes had been tried out for five months it was seen that the first or meetings of crafts was not as successful as the second in which the foremen and general foremen of all crafts met together. This was attributed to the fact that each craft meeting was too small, there being only six to ten foremen at a meeting and also because the competitive spirit shown at the meetings of the various crafts was entirely lacking. As a result a reorganization covering the entire construction was effected along the lines of the second scheme, wherein the foremen and general foreman of all crafts held a safety meeting at a regular hour on the same day of each week. This particular time every week came to be known on the job as the "safety hour."

The procedure followed at these meetings is of interest:

(1) Roll call—(attendance averages 90 per cent; 10 per cent absent due solely to rush work).
(2) Reading of minutes of last meeting—(copies go to resident engineer and home safety office).
(3) Safety committee chairman reads inspection report, which is followed by open discussion.
(4) Chairman asks for any suggestions.
(5) Safety engineer gives brief talk on current accident news, and the length of time which the various crafts have gone without accident.
(6) Frequently an injured man is brought in to the meeting to tell in his own words how he was injured.
(7) Every third meeting a speaker from the outside is secured to give a short talk on some particularly interesting phase of safety work.

The safety engineer always made it a point to give assistance to the chairman outside of meetings, so that he could keep them going smoothly and in the proper channels. The safety engineer's stenographer recorded the minutes and acted as secretary under the new scheme. At all these meetings the safety engineer kept himself in the background as much as possible, but he was ready, should discussions lag or subjects be found wanting, to start something new and keep the meeting alive. In all the meetings held he had occasion but once to take the initiative. The great virtue of these foremen's Safety Meetings was to give Safety work a serious place in the workmen's eyes.

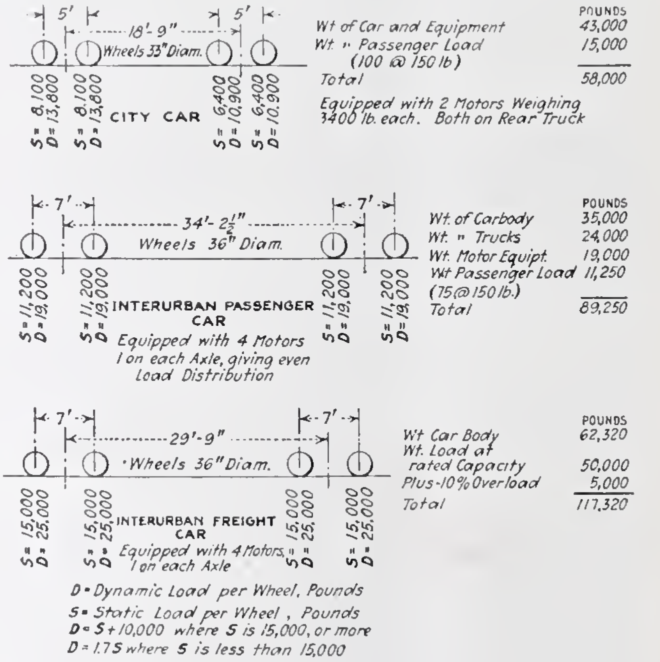
Although the safety committees submitted written reports of their findings at the next meeting and copies went to the resident engineer, it was their endeavor to take up on the spot with the foreman affected—not with the men—all points needing correction. In the majority of cases this was possible, because on construction work a foreman is generally to be found near his men. Of prime importance was the follow-up of the committees' reports subsequent to the meeting at which they were presented and prior to the next meeting at which the status of the recommendations was always given. Nothing will kill a safety committtee's interest more quickly than to see no action taken on its recommendations. The safety engineer made this follow-up and went directly to the division engineers, when necessary, to see that the recommendations were carried out. When a recommendation was turned in which it was impracticable to carry out, the safety engineer had the division engineer come to the next meeting and state frankly why it could not be done. Frequently this resulted in some excellent discussions.

You need have no fear of construction safety committees swamping you with a lot of impossible suggestions bearing on structural changes. On the contrary, you will find that their recommendations bear chiefly on safe working conditions as applied to ladders, scaffolds, shoring, walkways, tools and equipment. In this respect, we have found our construction safety committees far more practical than those used on operations. But let me caution you in dealing with your committees to be absolutely frank and always acknowledge their suggestions with honest reasons, if you find it necessary to turn any of them down. We have also found that the men appreciate a designating mark for their service on the committee, so we give them a safety committee emblem.

Again on this job the effectiveness of the safety work was shown in the difference between the actual costs, including compensation, plant hospital maintenance, doctor's salaries and the cost of maintaining the safety department, amounting to $8,695, for seven months, as against the premium of $16,768 which we would have had to pay on employes' liability insurance carried outside—a net saving of $8,073 for the period. An average annual frequency rate of 100.1 and an average severity rate of .50, calculated on the Federal basis, was maintained for the first eight months of the work. I regret that the September figures are not yet available.

Typical Dynamic Load Diagrams for Electric Railway Cars

Mr. R. C. Cram, Engineer of Surface Roadway, Brooklyn Rapid Transit System, in a recent issue of the Electric Railway Journal has a discussion on the selection of rails for electric railway service, and in this connection shows some typical load diagrams as having an important bearing on the subject. We have reproduced the diagrams in the belief that engineers interested in railway structures will be able to appreciate the increase in rolling loads and to make certain comparisons between the rolling loads on electric lines and those on steam railroad lines.


5'
18'-9"
5'
Wheels 33" Diam.
S = 8,100 D = 13,800
S = 8,100 D = 13,800
CITY CAR
S = 6,400 D = 10,900
S = 6,400 D = 10,900
POUNDS
Wt of Car and Equipment 43,000
Wt " Passenger Load (100 @ 150 lb) 15,000
Total 58,000
Equipped with 2 Motors Weighing 3400 lb. each. Both on Rear Truck
7'
34'-2½"
7'
Wheels 36" Diam.
S = 11,200 D = 19,000
INTERURBAN PASSENGER CAR
Equipped with 4 Motors 1 on each Axle, giving even Load Distribution
POUNDS
Wt. of Carbody 35,000
Wt. " Trucks 24,000
Wt. Motor Equipt. 19,000
Wt Passenger Load (75 @ 150 lb.) 11,250
Total 89,250
7'
29'-9"
7'
Wheels 36" Diam.
S = 15,000 D = 25,000
INTERURBAN FREIGHT CAR
Equipped with 4 Motors, 1 on each Axle
POUNDS
Wt Car Body 62,320
Wt. Load at rated Capacity 50,000
Plus-10% Overload 5,000
Total 117,320
D = Dynamic Load per Wheel, Pounds
S = Static Load per Wheel, Pounds
D = S + 10,000 where S is 15,000, or more
D = 1.7S where S is less than 15,000

Load Diagrams for Electric Railway Cars.

Joint Industrial Councils in Great Britain.—Seventy-one industries, representing about 2,000,000 workers, in Great Britain, had, up to May 13, 1919, taken steps toward the formation of joint industrial councils.

Some Present Practices in Track Work

At the 37th convention of the Roadmasters' and Maintenance of Way Association, held in Chicago on Sept. 16th, various papers were read on different phases of trackwork and other railway maintenance, and from abstracts of these given in the Railway Review the following quotations are made in the belief they will be of especial interest.

Motor Truck Haulage About Terminals.—Motor trucks are being used on several roads for hauling small material about terminals. In many situations such trucks can be run through city streets to various points about terminals and can distribute material more speedily than can be done by either motor cars or work trains in congested terminals. Fuel for crossing watchmen can also be conveniently distributed in this manner. Coleman King, supervisor with the Long Island R. R., uses a motor truck in such service covering a distance of 25 miles in different directions from the storehouse, for delivering small material in congested territory. H. Van Gorder, of the Chicago & Northwestern Ry., said that regular work train service in terminals was expensive and the motor truck in many situations was more economical. Mr. Lawrenz recommended the use of locomotive derricks for the transfer of heavy material in yards and terminals, and a very convenient auxiliary to be used with such a machine was a clamshell for handling fuel, cinders and other material to be unloaded or transferred.

Frogs With Curved Wings and Switch Point Tips.—C. J. Coon, of the Grand Central Terminal, New York Central R. R., New York City, recommended the use of frogs with curved wings, instead of straight wings, which require the turnout curve to end in advance of the point of frog. In some situations where he had been obliged to use frogs with numbers as small as 6 and 6½ he had found much satisfaction in constructing such frogs with curved wings.

There was a lengthy discussion on the use of manganese steel tips for switch points, and the practice of housing the switch point in various ways, in order to prevent rapid wear of the point where switching is heavy. Mr. Coon said he had more than 2,000 switches equipped with manganese steel points, the usual length of such tips being 20 to 36 in. He had found that while the cost of equipping the switch point in this manner was about double that of the ordinary plain point of open hearth or Bessemer steel, yet the point with manganese tip will wear six or seven times as long as will plain points, and the hardened tip on the point rail also saves wear to the stock rails. He kept a record of the service of some manganese points where traffic as large as 270 million tons had passed over the same. As a means of getting maximum wear from the switch point behind the hardened tip, he uses a tip not quite as high as the switch point rail in rear of it.

Housing Switch Points.—A member from the Pennsylvania R. R. spoke of the use of a milling machine for housing of switch points. This machine mills out the side of the rail head to a depth of ⅛ in., the recess being run to a feather edge in a length of 24 or 27 in., and the side of the rail head being slightly undercut, so as to properly house the end of the point rail. Other members spoke of the practice of housing switch points by kinking the stock rail, or the use of the so-called "double knuckle." Still another means of housing the ends of switch rails was to let the bend of the stock rail come in advance of the end of the point rail.

One member spoke of a switch where the traffic was so heavy that an ordinary point rail of open hearth steel would wear out in seven days, but by housing the point the service of a plain point rail at the same switch was 31 days. By using a guard rail in advance of the point the service of the point rail under the same conditions was 13 months.

In connection with the housing of point rails, inquiry was made as to what would be the result, in such practice, from creeping rails. The reply was that when a cast filler block is used at the heel of the switch point, if rail creeping occurs under such conditions the stock rail will move with it and there will be no interference with the operation of the point rail.

Method of Renewing Rail in Long Slip Switch Crossings.—An interesting method of renewing the rails in long slip switch crossings was described by a member from the Pennsylvania R. R. Short crossings, or those of large angle, were frequently assembled and lifted into place by steam derricks, but in this instance the slip switches were too long to be lifted in the ordinary manner. They were, however, assembled on suitable ground at a distance from the point of service and bolted up from end to end. They were then stiffened with long I-beams, in a manner to undergo lifting bodily, which was done by means of two steam derricks lifting at intermediate points, with two master carpenters' derricks at the ends. After being loaded upon the flat cars they were run on a parallel track to a point opposite the site. The work of disconnecting the old slip switch, lifting it out and lifting in the new one occupied an hour and twenty minutes.

Reinforced Concrete Slab Under Crossings. Another point of interest brought out was that the experience of railways with the use of reinforced concrete slabs under crossings has not always been satisfactory. While some members related experiences with these slabs which had proven serviceable and satisfactory, others told of disappointments in their use and said it had been necessary to blast them out and substitute stone ballast. Unfortunately the conditions of soil and drainage in connection with these unsatisfactory slabs were not stated.

Compensation of Engineers and Morale of Engineering Organizations

Under a recent date the State and Municipal Section of the Engineering Council's Committee on the Classification and Compensation of Engineers reports that 45 responses have already been received to its questionnaires sent out a few weeks ago. The following notes are supplied by the chairman of the commitee, Mr. Arthur S. Tuttle, M. Am. Soc. C. E., and deputy chief engineer, Board of Estimate and Apportionment of the City of New York.

In the case of eight services the morale is reported to be good, but in most of these it appears that the organization reported is a new one or that radical changes in compensation have recently been effected. In 20 reports no comment is made as to the present morale, while in 17 instances the general conditions are said to be as follows:

"Morale would be improved if adequate salaries were allowed."

"Practically all men are clamoring for more pay, but as our budget was fixed while the country was at war we are unable to secure the additional funds necessary to raise salaries further."

"Impossible to hold first class men at these rates. Morale is generally good."

"All want more money. Dissatisfied on account of low pay."

"Our organization is in a condition of unrest and change owing to small appropriation."

"Loyal enough generally, but dissatisfied with pay, and accept better offers readily. Difficult to fill their places at same rates."

"Excellent, but all employes desire increase in compensation over that already granted. New men cannot be obtained at previous salaries."

"Dissatisfied with present compensation."

"Force depleted. Employes leaving to take positions at greater compensation. Men remaining uneasy and dissatisfied."

"I might say that I thoroughly agree with the men in New York City who demand a flat raise of $500 yearly in all classes of the service."

"There is a decided spirit of unrest and dissatisfaction due to the fact that engineering salaries have not been increased in proportion to the advance in the cost of living, and to salaries and wages paid to non-professional men and skilled labor."

"Rate of pay tends to drive more active and self-reliant younger men out of this service—lowering general average."

"Majority of men feel they are underpaid."

"Lack of consideration for services rendered has discouraged the force."

"A general increase of $150 to $400, effective Sept. 16, 1919, has improved the morale of the force, which was affected both by a general reduction of force and the economic situation."

"Increasing restlessness on the part of the entire force due to lack of proper salary increases to meet growing expenses."

MANAGEMENT AND OFFICE SYSTEM

This section is published twice a month: (1) In the Waterworks and Hydraulic Monthly issue, and (2) in the Railway and Excavation Monthly issue. It covers what may be broadly termed "management engineering" as applied in the civil engineering and construction fields.

Henry Ford's "Secret"

By HALBERT P. GILLETTE, Editor.

Henry Ford has been frequently interviewed by magazine writers who were searching for the "secret" of his manufacturing success. Although he has given out several formulas, it is doubtful whether he has stated even the most salient causes of his phenominal achievement. I am of this opinion not only because it is the general rule that a successful business man is not enough of a philosopher to summarize and analyze all his methods, but because every one of the methods that Ford has named was not only well known prior to his use of it, but was in use by at least some of his competitors.

For example, he places foremost his plan of specializing on one model of automobile. He is so sure that it is a great economic rule to specialize that he advises shoe manufacturers to make only one size and model of shoe!

In a recent article I pointed out that no financial success is attributable entirely to one cause, but rather to a judicious application of many laws of management. Nevertheless, if several competitors in a given field, all progressive and ingenious, are badly outstripped in the financial race by one man, it generally happens that that man has either discovered or invented something new or is applying an old principle that his competitors are neglecting to apply effectively. Can it be that Ford has discovered some new principle of management? He disclaims having done so, but he does lay great stress upon his practice of specializing in one model of car.

So long ago as 1776 Adam Smith, in his "Weath of Nations," laid down the economic law of specialization in manufacture, although he termed it the principle of the subdivision of labor. Nearly every comprehensive treatise on political or industrial economics contains a more or less elaborate explanation of this economic law. It is well known to every one of Ford's competitors. Have they simply failed to follow it to its logical conclusion, while he has done so? If so, what is the logical conclusion?

It seems to me, after a careful analysis of the evident policies of Ford and his competitors, that he has taken a forward step in the application of the law of specialization, or rather, that he has applied another economic law coincidently therewith and in a manner to give full effect to the economy securable by specialization. Ford has unquestionably greatly increased the demand for his cars by lowering the price. This served not merely to attract customers away from other cars, but it converted into buyers of cars millions of people who would have bought none at all at the old high prices. This law of demand as affected by price is the one that Ford's competitors failed to apply with as great intelligence as he applied it.

Ford knew, of course, that if he could greatly increase his yearly output of cars he could substantially reduce the cost of manufacture. This invariably occurs, for several reasons, but two of the leading factors are (1) the subdivision of the manufacturing operations so as to utilize machines of a more special nature, and (2) the greater skill that workmen acquire through greater specialization of their operations. If, then, Ford could forecast roughly the reduction of cost per car as a result of doubling his annual output, he could announce in advance a lower price for his car. This he did, and startled the motor car world by his announcements of much lower prices. While other car manufacturers were lowering their prices only as fast as their production costs decreased in consequence of larger annual outputs, Ford took the bold step of making sweeping reductions in price prior to the actual reduction in cost of manufacture. He had the courage to base his selling price on his estimates of the reduced cost that would follow later on when his output had increased.

In February, 1913, the Ford factory made 16,000 cars with a force somewhat in excess of 16,000 men working 10-hour shifts, or at the rate of one car for about 260 man-hours work.

In February, 1914, the same factory, enlarged and equipped with better and more specialized machines, but operated by somewhat fewer than 16,000 men working 8-hour shifts, turned out 26,000 cars, or one car for about 128 man-hours work.

In one year's time Ford had more than cut in two the number of hours labor required to make a car! This had been accomplished partly by stirring the ambition of the employes through paying a minimum of $5 per 8-hour day to unskilled workers, and proportionately more to skilled workers; but the increased output was largely due to improved machinery and greater specialization of machines and men. However, the 60 per cent increase in the number of cars made per month would not have been justified had it not been possible to market the increased output. Ford had made the marketing of this increase a certainty by lowering the price in advance of selling the cars. He had also ingeniously secured a vast amount of free advertising of a still lower price by announcing that, if his sale of cars exceeded 300,000 for the year, every purchaser would receive a substantial rebate on the purchase price. This itself was a novel idea, but note how it was made to fit in with the major idea, namely, advance announcement of a lowering of the selling price as the annual output increased.

Now, turn to the financial result. For the twelve months ending July 31, 1916, Ford produced 508,000 cars, the gross selling price of which was $206,876,000, or $407 per car. The profits on these sales were $59,994,000, or nearly $120 per car, or about 30 per cent of the selling price.

Had any of Ford's competitors been told before this achievement that it was possible to manufacture such a car for $287, exclusive of plant interest and depreciation, the teller of such a tale would have probably been regarded either as hopelessly ignorant or as a visionary fool.

Although it has been demonstrated, times without number, that manufacturing costs can be startlingly reduced when the number of units of output is considerably increased, still there are relatively few instances of a marked reduction in selling price offered in anticipation of a lower production cost. There are undoubtedly many fields where the demand can not be greatly stimulated by lowering selling prices, but it will certainly pay any business man to study his own field carefully before concluding that a reduced price will not produce a greater demand.

Action of Muriatic Acid on Manila Rope.—At the instigation of the National Safety Council, an investigation has been undertaken by the Bureau of Standards, Department of Commerce, to determine the action of muriatic acid on manila rope. The effect of this acid or its fumes on rope of this kind is a great mencae, as the acid weakens the rope seriously without any superficial trace of the action being noticeable to the eye. When rope is exposed to this acid, as, for instance, when it is used in blocks and falls of swinging staging when washing down brickwork, etc., many serious accidents have resulted, some of which have been fatal, owing to the fact that the rope has been weakened through contact with this acid or its fumes.

Cost Keeping Under Cost-Plus-Fixed-Fee Contracts

By F. A. WELLS,

Vice President and Treasurer, Wells Brothers Construction Co., Chicago.

No contractor who values his capital can afford to do without adequate cost records, both as a check on the job in progress and as a basis for future estimating. Yet the simpler that system of accounting, the better, and any refinements further than those necessary to give the actual required data are a waste of time and money. Some contractors keep their books under their hats or in their left-hand pocket of their coats, where all invoices go preparatory to paying. At the opposite extreme are firms who maintain a complicated system of accounts, both at the job and at the home office. Accounting methods sufficient for the lump-sum contract may be insufficient for the cost-plus-fixed-fee contract, under which the owner and architect must have access to the accounts at all times.

We have found the following system to be adequate for cost-plus jobs and with only a few changes this is the system put into effect on such typical work as the four warehouses we have built for Montgomery Ward & Co. at Chicago and Kansas City, the Butler Brothers' Chicago mail order warehouse, Rand McNally & Company's Chicago publishing house and other similar work in this country and Canada.

Occasionally we have found an owner who prefers to be given such data as will permit his own accountants to keep a complete system of books. Generally, however, our accounts, kept on the job and open at all times for inspection, are considered sufficient, in view of the detail statements we render to the owner every two weeks—bearing the approval of the owner's representative, who is designated for that purpose. We urge owners to have their auditors frequently make examinations of accounts for their own satisfaction.

The system we are now using is briefly the keeping of—1. Cashbook, voucher record and ledger, combined; 2. Invoice and payroll register, combined; 3. Detail cost record; 4. Accounts payable record (vendor's accounts).

The cashbook, voucher record and ledger is used for the recording of all cash received, cash disbursed by vouchers and all journal entries.

The invoice and payroll register is used for the recording of all invoices and payrolls. The invoices and payrolls are numbered consecutively. This hregister has columns for date, invoice number, vendor's name, total amounts, both debit and credit, and individual columns for the 20 main accounts used in distribution of costs. The register represents an absolute detail control of all approved charges to the job as only audited and approved items are given a register number or entered. The payrolls are given register numbers and approved the same as invoices. The office copies of all invoices are filed in numerical order in an ordinary letter file drawer, and bound in numerical order, in lots of 50 to 100, using an ordinary heavy file folder for cover, clamping the invoice to the folder.

The detail cost record is used for the recording in detail the distribution of costs among the main accounts as shown on invoice register.

The accounts payable (or vendor's accounts) record is used for the recording of all invoices from vendors. After the invoices have been entered in the invoice register and detail cost record book, they are entered as a credit to vendor in accounts payable. Each vendor has a separate page or sheet. After entry is made, it is placed in file under vendor's name until ready for payment. When payment is made same is vouchered and charged to accounts payable (vendor's account) and cash credited.

Office Routine of Purchase Order, Invoices and Voucher.

Issuance of Purchase Order—In Quadruplicate: The original of order is sent to vendor, the duplicate is filed numerically (which forms order register), triplicate is filed in open order file (vendor's name order), quadruplicate (which forms material receipt or tally sheet) is filed by the office material clerk awaiting receipt of material.

Receipt of Material: Upon receipt of materials, the office material clerk checks and signs the material receipt portion of the order and file completely with supporting delivery tickets, etc., awaiting invoices.

Checking and Auditing Invoices: Invoice upon receipt is checked against material receipt or tally sheet for receipt of material. Extensions, prices and footings are checked and certified. Cost distribution is checked and entered. Invoice is then audited for discount and cost distribution and certified. Invoice then passes to the superintendent for his approval and the approval of the owner's representative.

Entry of Approved Invoices in Invoice Register and Vendor's Account: Upon return of approved invoice from the superintendent, the bookkeeper gives the invoice numerical register number and enters in the invoice register. Only fully approved invoices are given register number. Invoice is then posted to the credit of the vendor in accounts payable account and a charge to the detail cost record.

Journalizing Accumulated Totals of Invoices Registered to Ledger: Accumulated totals in the invoice register are journalized in the ledger (which is also the voucher record) at daily, weekly or semi-monthly periods as is found practical.

Voucher Check: We have found the voucher check system to be the most convenient. The voucher is made in quadruplicate at the construction office on the job and the approval of the owner's representative is often indicated on all copies of the voucher. The check, or original voucher, goes to the vendor, the duplicate to our general office for our records, the triplicate is kept as the job record and the quadruplicate is the "owner's copy," which is forwarded to the vendor with original to be receipted by him and returned. At intervals we furnish the owner with statement showing vouchers paid and receipted vouchers attached.

Since the major purpose of cost accounting is to give an adequate basis for future estimating, it is important that so far as practicable the form of cost accounting shall follow the form of estimate. This is not practicable to the last subdivision of each of our general accounts, but sufficient to permit intelligent use of all cost figures. With such figures it is possible to compare not only final costs, but costs at any stage of the job, with the original estimated cost for that portion of the contract. We frequently divide our estimate by floors, in the case of a many-storied building, in order to have a check upon quantities and upon expenditure at several stages of the work.

Distribution of Accounts.

We use the decimal system of classification of accounts. The classifications number 100 to 600, inclusive, and 900 are for our general books which embrace the assets and liabilities, revenues and income accounts—we will omit these in our discussion of construction cost accounting in connection with cost-plus and fixed-fee contracts.

The general distribution is under the following headings:

700 and 800 Construction Costs (Summary of General Headings).

- 710 Excavation
- 720 Caissons
- 730 Footings
- 740 Trench and Wall
- 750 Concrete and Fireproofing
- 760 Masonry
- 770 Carpentry
- 780
- 790
- 800 Plant Expense
- 810 Field Overhead
- 820 Extra work
- 830 Subcontracts
- 840 (Subcontract) extra work
- 850
- 860
- 870 Repair contracts
- 880
- 890 Company expense (Not chargeable to owner)

The sub-divisions of headings 710-790 are between the items labor (1), material (2) and liability insurance (3). Thus labor in excavation would be 711, material in excavation 712, and liability insurance in excavation 713.

A further division of the various kinds of labor and materials is made. The following classifications illustrate this point:

Labor—711
- 711.01 Digging (general)
- 711.02 Digging sub-basement
- 711.03 Sheeting and shoring banks
- 711.04 Shoring adjacent building

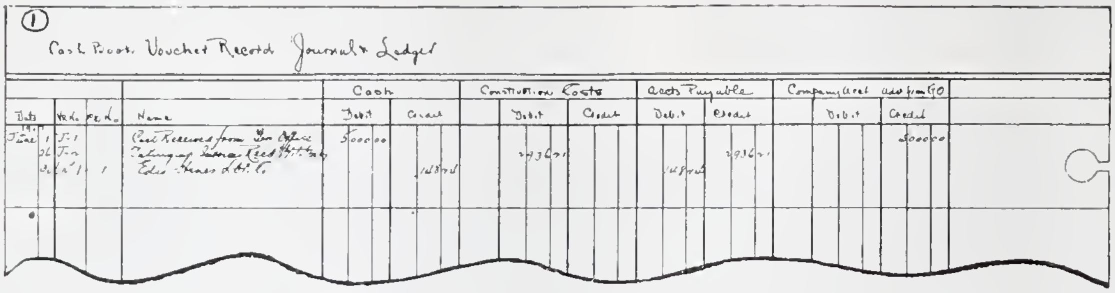
Material—712
- 712.01 Lumber
- 712.02 Underpinning adjacent building
- 712.03 Rings (steel)
- 712.04 Cement

Liability Insurance—713

For convenience we have listed the charges of labor and material in the order they usually appear in building construction costs:

Labor:
- .01 Digging (general).
- .02 Digging (sub-basement).
- .03 Sheeting and bracing banks.
- .04 Shoring adjoining building.
- .05 Underpinning adjoining building.
- .06 Pumping.
- .07 Backfilling and grading.
- .08 Cutting old footings.
- .09
- .10 Placing lagging and rings.
- .11 Ventilating.
- .12 Mixing and placing concrete.

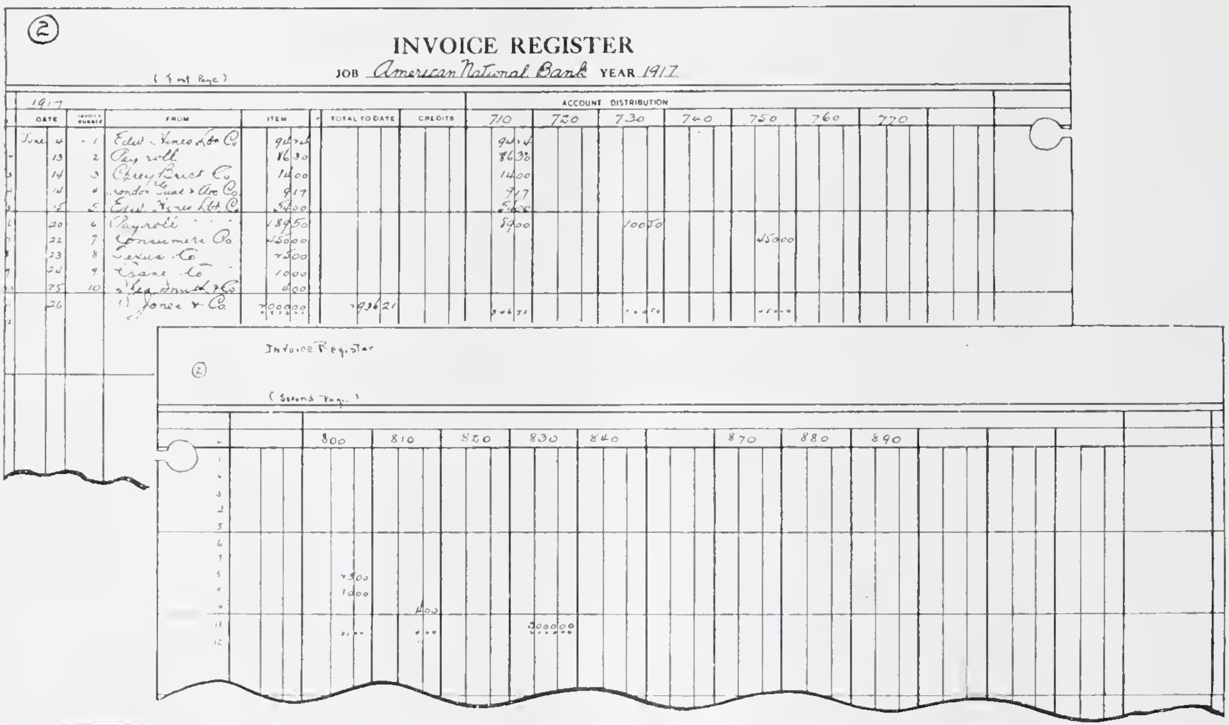
Material:
- .01 Lumber.
- .02 Underpinning adjoining building.
- .03 Rings (steel).
- .04 Cement.
- .05 Sand.
- .06 Stone.
- .07 Brick.
- .08 Wall tie and inserts.
- .09 Steel (structural).
- .10 Steel (reinforcing).
- .11 Nails and wire.
- .12 Clamps, purchased or rented.



①

Cash Book, Voucher Record, Journal & Ledger

Date	Vo. No.	F. No.	Name	Cash Debit	Cash Credit	Construction Costs Debit	Construction Costs Credit	Accts Payable Debit	Accts Payable Credit	Company Acct. adv. from G.O. Debit	Company Acct. adv. from G.O. Credit
1917 June 1	J-1		Cash Received from Gen. Office	5000.00							5000.00
26	J-2		Taking up Invoice Reg. Total			2936.21			2936.21		
30	1	1	Edw. Hines Lbr. Co.		148.24			148.24			



②

INVOICE REGISTER

JOB American National Bank YEAR 1917

(First Page)

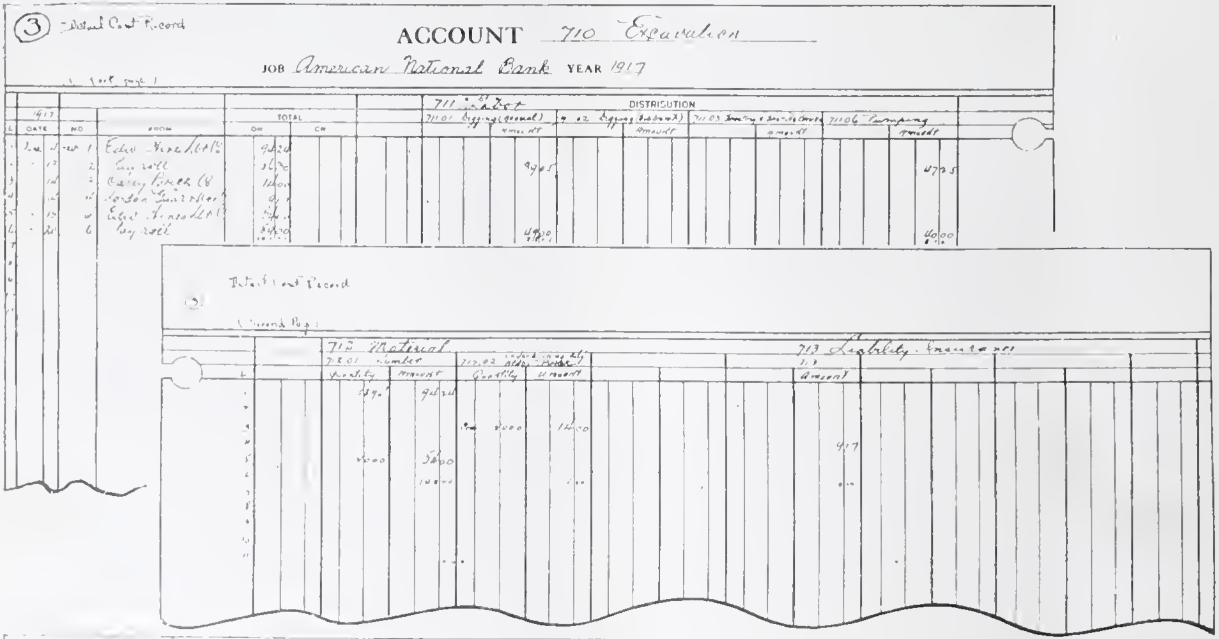
1917 Date		Invoice Number	From	Item	Total to Date	Credits	710	720	730	740	750	760	770
June	4	1	Edw. Hines Lbr. Co.	94.24			94.24						
	13	2	Pay roll	86.30			86.38						
	14	3	Cheney Brick Co.	14.00			14.00						
	14	4	London Guar. & Acc. Co.	9.17			9.17						
	15	5	Edw. Hines Lbr. Co.	54.00			54.00						
	20	6	Payroll	189.50			89.00		100.50				
	22	7	Consumers Co.	450.00							450.00		
	23	8	Texas Co.	25.00									
	24	9	Crane Co.	10.00									
	25	10	Geo. Smith & Co.	4.00									
	26		J. Jones & Co.	3000.00	[illegible]		[illegible]		[illegible]		[illegible]		

Invoice Register

②

(Second Page)

	800	810	820	830	840		870	880	890
8	25.00								
9	10.00								
10		4.00							
11				3000.00					



③ Detail Cost Record

ACCOUNT 710 Excavation

JOB American National Bank YEAR 1917

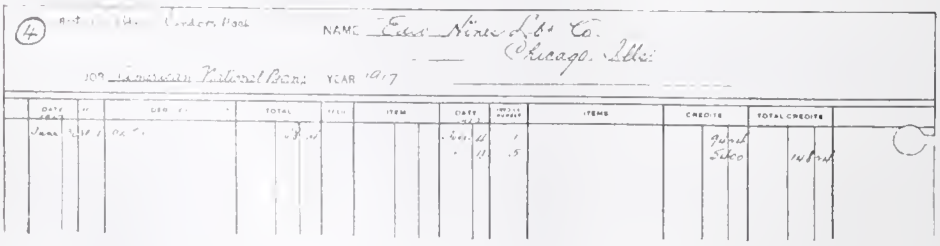
(First Page)

1917 Date		No.	From	Total Dr.	Total Cr.	711 Labor: 71101 Digging (General) Amount	71102 Digging (Bedrock) Amount	71103 Amount	71106 Pumping Amount
June	4	1	Edw. Hines Lbr. Co.	94.24					
	13	2	Pay roll	86.30		39.05			47.25
	14	3	Cheney Brick Co.	14.00					
	14	4	London Guar. & Acc. Co.	9.17					
	15	5	Edw. Hines Lbr. Co.	54.00					
	20	6	Pay roll	89.00		49.00			40.00

Detail Cost Record

(Second Page)

712 Material — 71201 Lumber: Quantity, Amount; 71202 Brick: Quantity, Amount — 713 Liability Insurance: Amount



④ Accounts Payable Record

NAME Edw. Hines Lbr. Co.
Chicago, Ills.

JOB American National Bank YEAR 1917

Date		Credits	Total Credits
June 4	1	94.24	
15	5	54.00	148.24

No. 1—Page from Combined Cash Book, Voucher Record and Ledger. No. 2—Pages from Combined Invoice and Payroll Register. No. 3—Pages From Detail Cost Record. No. 4—Page From Accounts Payable Record.

.13 Building forms (general).
.14 Building forms (exterior columns).
.15 Building forms (interior columns).
.16 Building forms (spandrels).
.23 Lay brick.
.26 Bend steel.
.35 Set cut stone.
.44 Fit and hang doors.
.56 Unload and handle material, etc.
.60 Clean up rubbish.
Add as many new accounts as are needed.

.13 Tile
.14 Protection (lumber, etc.).
.15 Terra cotta
.16 Granite.
.25 Frames and sash.
.30 Interior trim.
.35 Coping.

Should charges be made in connection with concrete and fireproofing under subdivision 750, they would follow the same order as in excavation:

751.12 (Labor)—Mixing and placing concrete.
752.04 (Material)—Cement.
753 Liability insurance.

Or, Carpentry—Subdivision 770:

771.44 (Labor)—Fit and hang doors.
772.25 (Material)—Frames and sash.
773 Liability insurance.

Classification of Plant Expense.

Subdivision 800 covers plant expense and conforms with the sub-classification of the 700 accounts as much as practicable.

The following are the headings under 800:

801 Excavation.
802 Caissons.
803 Footings.
804 Sawmill.
805 Concrete and fireproofing.
806 Masonry.
807
808
809 General (items charged to general equipment).

A further typical subdivision of the accounts under this heading is:

801 Excavation.
801.1 Transportation (of equipment plant).
801.2 Erection of equipment—
  801.21 Labor.
  801.22 Material.
801.3 Equipment on charge and credit basis—
  801.31 Labor.
  801.32 Material.
801.4 Rental of equipment.
801.5 Fuel, lubricants and power.
801.6 Repairs.
801.7

Should charges to plant in connection with concrete and fireproofing be made, they would be charged as 805, with divisions shown above.

Field Overhead.

811 Salaries, General Labor and Expense:
  811.1 Superintendent and engineers.
  .2 Office employes.
  .3 Materialmen and timekeepers.
  .4 Laying out building.
  .5 Watchman.
  .6 Waterboys.
  .7 Toolmen.
  .8 Liability insurance, superintendent and watchman.
  .9 Traveling expenses, superintendent, engineer and office men.

812 Engineering Expense:
  812.1 Plans, detail and engineering supplies.
  .2 Photographs.
  .3 Engineering service.
  .4 Architect's fees.
  .5
  .6
  .7
  .8
  .9

813 Office Expense:
  813.1 Rent, light and heat.
  .2 Stationery and printing.
  .3 Telephone.
  .4 Telegraph.
  .5 Postage and expressage.
  .6 Rent on adding machine and typewriters.
  .7 Furniture.
  .8
  .9 Miscellaneous office expense, towels, etc.

814 Other Fixed Field Expenses:
  814.1 Bonds (maintenance and construction).
  .2 Permits and licenses, boiler inspection.
  .3 Fire insurance.
  .4 Legal services.
  .5 Burglar insurance.
  .6 Association dues.
  .7 Advertisements.
  .8 Floor tests.
  .9 Ring tests.

815

816 Temporary Structures (Labor and Material):
  816.1 Offices.
  .2 Toilets.
  .3 Toolhouse, blacksmith shops, storage sheds, etc.
  .4 Stairs and ladders.
  .5 Fences, sidewalks, covers and other enclosures.
  .6 Temporary platform and driveways.
  .7
  .8 Repairs and protection to adjacent property.
  .9 Protection to public utilities.

817

818 Temporary Light, Heat and Power:
  818.1 Light.
  .2 Heat.
  .3 Power.
  .4
  .5
  .6

819 General Cleaning:
  819.1 Labor.
  .2 Teaming.
  .3
  .4
  .5

820 Extra Work:
  821.1 Use as many numbers as accounts charged.
  822

830 Subcontracts:
  831 Wrecking, excavating and shoring, etc.
    .1 Wrecking—Contract.
    .2 Excavation—Contract.
    .3 Shoring—Contract.
    .4

832 Heating, Plumbing, Wiring, Elevators, etc.:
  832.1 Sub-heading for each kind of sub-contract.

833 Interior Construction.
834 Painting and Glazing.
835 Millwork.
836 Roofing
837 Fireproof Doors and Windows.
838 Interior Finish
839 Structural Steel.
840 (Extra Work, Sub-contracts)
  841 Sub-heading for each kind of [illegible]

850
860
870 Repair Contracts [illegible]

890 Company Expense [illegible] charged to [illegible]
  891 Sub-headings for each kind of expense.

Statement of Construction Cost.

At stated periods we take from the cost record a summary and detail statement of construction costs in the following form:

Acct. No.
Name of Acct.
Item Amt.

Cost per Unit
Est. Cost
Difference

The last column is in black or red, naturally the red items will have careful scrutiny to ascertain why costs are running above estimate. This statement is primarily for our own use, but the owner may have a copy if he wishes.

Owner Knows Total Expenditure at All Times.

Under the cost-plus-fixed-fee contract the owner generally furnishes the funds to finance the contract. We maintain an entirely separate bank account for each cost-plus contract representing the owner's funds, and where agreeable to the owner, we arrange for the owner's representative to countersign all checks drawn by us on this account. At the start of the work we furnish an estimate of the anticipated amount of labor and material bills covering an initial period of two weeks or more to the owner, who then advances the funds to cover these requirements. When the owner's receipted copies of vouchers covering this period are returned from the vendor's, a statement is given to the owner showing amounts actually paid for payrolls, materials and subcontract work, with receipted vouchers attached. That total is then credited to us by the owner on account of contract.

The advantages of having all accounts handled at the job are apparent. The distribution, if not clear from the purchase order, can be referred to the superintendent and the fact that the books of accounts are at all times open for the owner's inspection is an assurance to him of honest treatment. The fact that he approves purchases of materials before made and again has the opportunity of questioning invoices prior to payment leaves the control with him and prevents the accumulation of minor, disputed items, which if left for settlement until the completion of the contract might not be readily explained.

But a system of accounts, no matter how perfect, cannot influence the cost of work except as it points out from time to time divergence from the preliminary estimate and unless such differences are promptly taken in hand, the reasons investigated and the remedy applied. The success of work under the cost-plus contract is still dependent upon the integrity of the contractor and his ability to perform.

We have used this system of accounting with entire satisfaction to firms mentioned above in this article and to many others, such as the Wm. Davies Company, Ltd., the largest packers of Canada; the Robert Simpson Co., Ltd., Toronto, for whom we built originally on the cost-plus-fixed-fees basis, and from whom we have received many repeat orders, being now engaged in work at Halifax on this same basis. This is adequate proof that the cost-plus contract is workable and that the owners not only feel safe, but prefer this method because under it 90 per cent of the savings under the preliminary estimate accrue to the owner, because the 10 per cent retained by us is a reasonable incentive for us to make every possible saving and because additional costs incurred through no fault or omission of the contractor are rightly chargeable against the builder and should not reduce or wipe out his profit. There is incentive for the contractor to make all possible savings under both old and new contract and some of the savings must go to the contractor to give him that incentive. Ten per cent we believe to be adequate and the 90 per cent going to the owner builds up for us a good-will account which practically assures repeat orders as new work becomes necessary. The building of a relationship which will insure repeat orders is just as important in contracting as in merchandising.

Surveying Methods for Subdividing Oil Lands

By EDWIN P. ARNESON.

Of Walton & Arneson, Engineers and Surveyors, San Antonio, Tex.

The exploitation of oil lands has developed a lively business in the selling and buying of mineral rights of real estate lying even remotely from the proven fields. For the purposes of leasing, owners of large tracts are subdividing their holdings into blocks as small as 10 acres and are calling upon the engineer to prepare the required maps. As the prevailing low lease values in such instances do not permit the expense of much surveying, the engineer faces the problem of laying out the subdivision with a minimum of field work, yet his data must be complete enough to enable him to stake out on the ground any particular block in the tract. The writer recommends the following procedure as meeting the foregoing requirements satisfactorily.

(1) A boundary survey is made of the entire tract to be subdivided. The resulting error of closure should not be greater than 1 in 2,000. As a rule no more field work than this is necessary.

(2) Latitudes and departures of all sides are then computed, using as a meridian that bearing possessed by most of the sides. For instance, if most of the sides of the boundary bear North 45° East calculate all latitudes and departures as from a meridian which has a course of North 45° East.

(3) Compute the total area of the land by the method of double meridian distances.

(4) Then, by the use of the latitudes and departures already obtained, and selecting some convenient point as origin, the coordinates of every corner of the boundary are quickly found.

(5) Prepare map by plotting the boundary by coordinates. Check the lengths of sides by scaling and the bearings with a protractor.

The engineer now has an accurate map before him and can proceed with the subdivision. He can lay out the regular blocks in squares and the irregular tracts along the boundary and elsewhere in such shapes as he finds convenient. The dimensions and areas of the latter he can compute from the data presented by the coordinates of the boundary corners. When this is done he has a good check on his work by comparing the sum of the areas of all interior blocks with the gross area of the original tract. When he is ordered to stake out on the ground any interior or border block the same coordinates of the boundary corners furnish him the necessary information to do so accurately.

Supplement to Manual American Railway Engineering Association

The latest (1919) supplement to the Manual of Recommended Practice of the American Railway Engineering Association has just been issued as a part of Bulletin No. 217. This supplement contains the following matter:

Roadway: Means for Prevention or Cure of Water Pockets in Roadbed.

Ballast: Suggested Diagram for Organization and Distribution of a Ballast Raising Force of 77 Men.

Rail: Standard Test for Rail Joints.

Track: Plans for Split-Switches, Split-Switch Fixtures, Rigid Frogs and Spring Rail Frog.

Buildings: Definitions, Coaling Stations, Dial Scales, High Platforms at Passenger Stations.

Signals and Interlocking: List of Findings, Conclusions, Standards and Specifications of Railway Signal Association.

Water Service: Quality of Water, Methods of Treatment and Results Obtained Therefrom. Efficiency of Water Softeners. Foaming and Priming. General Principles of Water Supply. Instructions for Care of Water Stations.

Yards and Terminals: War Emergency Yard Improvements. General. Ocean Terminals. Catechism of Yard Design and Operation. Track Scale Specifications.

Iron and Steel Structures: Column Tests. Specifications for Bronze Bearing Metals for Turntables and Movable Railroad Bridges.

Uniform General Contract Forms: Industry Track Agreement Form. Agreement Form for Interlocking Plant.

Labor Conditions in the Maintenance of Way Field

A short time ago the Railway Age addressed a questionnaire to a number of maintenance of way officers in various parts of the country, soliciting replies to the questions given below, covering matters of actual fact as well as expressions of personal opinion regarding labor problems:

(1) The number of men employed now as compared with a year ago and normal pre-war times.

(2) The effect of the higher wage rate in increasing the efficiency of the existing forces, in attracting a better supply of labor, etc.

(3) The effect of the 8-hour day on increased efficiency, the ability to secure and hold men, etc.

(4) The effect of the reported exodus of foreign labor.

(5) The adequacy of supply of skilled and unskilled labor.

(6) The dissatisfaction with wage scales for men and foremen in the various branches of work.

(7) The general unrest among laborers.

(8) General comments regarding other influences.

An analysis of the replies received, as made by the above mentioned journal, is herewith briefly abstracted.

The number of men at present employed on maintenance is about the same or somewhat less than in years past; the figures must be considered, however, in the light of the fact that they are generally on a basis of the 8-hour day, while the totals for other years are generally for a 10-hour day. This amounts to a reduction in the hours of labor of 20 per cent, which is increased by the new rule that traveling to and from work should be done during the regular working hours, in contrast to the old rule, under which the men should travel in one direction on their own time.

The supply of labor has been short generally owing to the exodus of Italians, Greeks, Poles and others who have returned to their native lands in large numbers.

Opinions on the efficiency of wage advances in holding the supply of labor or attracting a better class of men seem to be divided. The question reduces to one of competition. Where the railroad rate is better than that offered by other employers the effect has been good, but in large industrial centers where the men have opportunity to get better paying jobs, the railroad work reverts to the old status in which it attracts only the least desirable class. In rural districts, on the other hand, the class of men now employed is better than it has been for several years. Thus, in the Middle West in particular, the railroads have been able to employ local native help to the almost entire exclusion of the foreigner. This return to old-time conditions has been very welcome, for it not only serves as a compensation for the increasing scarcity of the alien class, but gives the roads a more intelligent and agreeable type of workman to deal with and largely removes the need for camps and commissary facilities.

A number of maintenance officers reported that the 8-hour day was not held in favor by the men, as they preferred to work 10 hours and earn the additional wages.

In the majority of cases the reports indicated a feeling that no such increase in efficiency has taken place as might reasonably have been expected with the shorter day and the higher wages, and while the higher rate has attracted a better class of men in some cases, the general observation is that the efficiency has been lessened. One railway officer reports an improvement which he believes has resulted from the shorter working period, but the remaining statements report no improvement, if not a definite retrogression. Several replies give good reasons for this. One states, "Regular track men now have longer hours for leisure, for cultivation or for other occupations and for pleasure. In consequence they are less fit to give a full day's work by the physical exhaustion of these additional occupations." Another says of the Mexicans that the shorter working day gives them more time to get into trouble.

There are two prime motives that will tend to make a man work harder. First, the desire to hold his job and, second, eagerness for better pay. The first of these motives is entirely ineffective during any labor shortage, for as soon as a man knows there is no one to take his place, he is not going to worry much about his job. Labor has been scarce so long in this country that the indifference of the laborer as to the opinion of his boss has become almost insolence.

The second motive can be utilized to get more effort out of the men only when there is some relation between the increased effort and the rate of pay, and this fact must be clear to the men. No recognition has been taken in the wage advances by the Railroad Administration, and the feeling of the men, based on their experience, is that the force and effectiveness of their representations before the Board of Wages and Working Conditions are infinitely more important in obtaining a raise than any extra effort which they put into their work.

This current unrest has been ascribed to several agencies, chief among which has been mentioned (1) dissatisfaction with wage increases as affected by the high cost of living, (2) the organized labor movement and (3) the spread of anarchistic doctrine. From the information obtained the importance of these influences, at least insofar as they concern maintenance of way employes, is about in the order named with the third of minor or very slight importance in most cases.

Necessary as any organization of workingmen may be to secure recognition of their contentions and grievances, it is an unfortunate fact that the formation is not conducive to increased effort on the part of the individual. In the case of the maintenance of way employe, this has not been caused so much by agitation on the part of the organizer as by the policy of the Railroad Administration in dealing with the men. For instance, one report states that the foremen "have been more or less dissatisfied for the reason that the men know that their immediate superiors have little or nothing to do with the increases and there has been a natural tendency not to respect the foreman or officers."

One officer describes the condition as follows: "I believe that well over 50 per cent of the men are decidedly against any wage trouble, but on account of the Administration policy of forcing all men to organize and deal only with organized units many of the more stable classes of men have been forced into the organization and are now dominated by force and fear of radical element."

The Air Drill Repair Man Important Factor in Reducing Maintenance Costs

The idea that an air drill is "fool proof," and that any person on the job can repair it, is a mistake, writes Harry E. Scott in the Engineering and Mining Journal. A drill must be cared for properly, as well as any other piece of machinery. No matter how good the operator, it needs overhauling at certain intervals, in a shop fitted for that purpose and provided with a meter for testing the amount of air used. When a compressor making 2,000 cu. ft. of air a minute has to be run at maximum speed to furnish air to a number of drills which, if in good condition, would use only 1,500 cu. ft., there is something wrong. In most cases it will be found in the air drill.

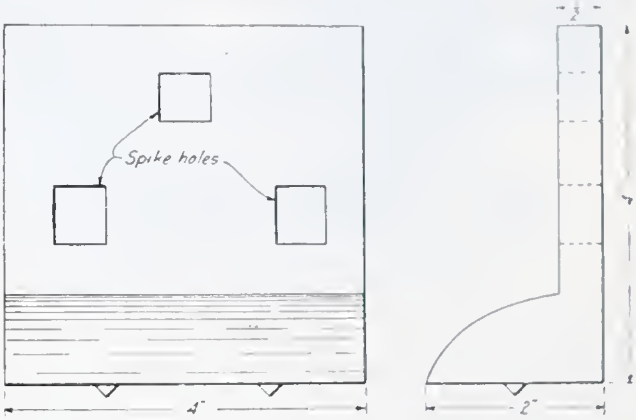
The air drill repair man, or machine doctor, as he is often called, is an important factor. The best repair men are those who have had a few years' experience running machines, and who are handy with tools and mechanically inclined. They know from experience the work to be done, and realize the troubles of the runner, which are many. A man of this kind who had become familiar with the cost of drill parts, and learned to throw nothing away that could be worked over and give efficient service, took a job. During the first 10 days he picked up over $900 worth of drill parts from the dump and junk-pile. These were used and gave as good results as new parts from the storeroom would have done. They had been thrown away by the man who was repairing drills; and it had taken him only a short time to do it, and with only 16 machines on the job!

Any property using a small number of air drills can support a good repair man—one who can keep the drilling speed up (with sharp steel) and the maintenance cost down. With the machines in good condition, sharp steel, plenty of air, and the right man on the crank, there should be no kick from the office concerning the number of feet drilled.

Railway Electrification in Foreign Countries.—European and South American countries, with the exception of England alone, lack an adequate supply of fuel, but many of them, including Norway, Sweden, Switzerland, Italy, Spain and Brazil, have large amounts of water power, while France has a moderate amount. These resources, combined with the high cost of fuel, make extensive railroad electrification in these countries inevitable sooner or later. The neutral countries will probably be the first to undertake this work. Switzerland has a program covering a term of years well established, while both Norway and Sweden are giving active consideration to definite projects. In England, a considerable amount of electrification is in contemplation along with the general plan for the electrification of industry. A French commission, composed of government and railroad engineers, have already visited the United States in order to thoroughly familiarize themselves with American practice. The Italian government will continue their definite program as soon as financial conditions permit. An official Belgian Commission is already planning to rehabilitate with electric power at least a portion of the railroads destroyed by the Germans. In Spain, Brazil and South Africa as well, railroad electrification is under active consideration.

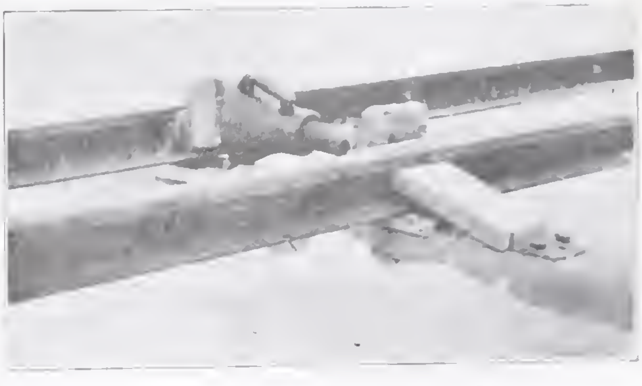
New Method of Bracing Shimmed Rails

Mr. D. McIntyre, roadmaster on the Can. Pac. Ry. at Fort William, Ont., has devised a rail brace clip or heel illustrated in the drawing and photograph shown herewith, taken from the Railway Maintenance Engineer. This clip is designed to make more effective the shim braces which are put in the track to make up for the decreased holding power of spikes in rail which has been shimmed on account of heaving. It consists of a small plate of malleable iron or forged metal, provided with three holes for driving spikes into the tie and with a vertical bearing surface to receive the end of the brace, this surface being provided with two pointed projections which enter the end of the bracing stick to prevent it from slipping.



Approximate Outline of a Shim Brace.

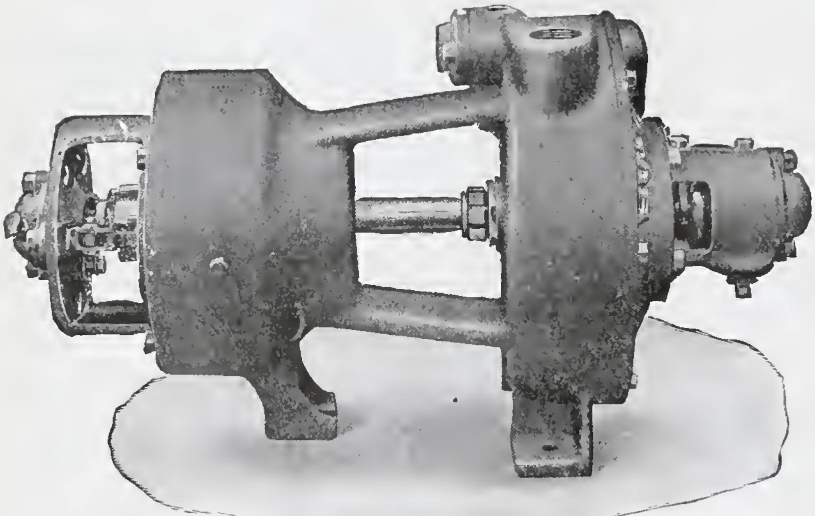
The effectiveness of a rail brace heeled with one of these clips instead of spikes driven in the ordinary fashion was tested by the inventor in the manner shown in the illustration. Two rails were placed side by side with just sufficient space between them to insert a small screw jack. The outer side of one rail was braced with a shim in the ordinary manner and the outside of the other rail was braced with a shim using one of the clips described above. The lateral wheel pressure on the rail was then simulated by screwing up the jack and it was found that the resistance of the brace supported by the clip was much more than that held by the spikes. These clips are now being tested under actual track conditions by a number of roadmasters in the vicinity of Fort William.



Method of Testing Efficiency of Shim Brace.

Small Electric Light Plant for Construction Operations

A compact steam turbo-generator unit, especially designed for lighting steam shovels, dredge boats, locomotive cranes, well drilling rigs and industries using a steam boiler whose lighting requirements do not run over 1 K. W., has been placed on the market by the Buda Co., Railway Exchange Bldg., Chicago. The steam turbine and the electrical generator are built compactly into one unit. The speed is controlled by an automatic governor and the field coils of the generator have a compound winding which keeps the voltage uniform on any lamp ranging from zero to the full capacity of the plant. This makes the operation of the lighting plant entirely automatic, requiring no other attention than turning on the steam when the lights are needed and turning off the steam when lights are no longer needed. The plant is made in two sizes. Model 1000, with a capacity of 1 K.W., has a length over all of 34 in., a width of 18 in., and a height of 20 in. Its net weight is 275 lbs. Model G. W. has a capacity of ½ K. W. It has a length over all of 30 in., a width of 14 in., and a net weight of 163 lb.



News Letter

St. Louis Items

I. J. Printy has moved his outfit on to a State Road job near Chatham, Ill.

John Brogan, Carrollton, Ill., has some drag line, also concrete work to let near Troy, Ill.

C. S. Jones, the boss station man, has started on several new jobs on the M. K. & T. R. R. in Oklahoma.

Stresenreuter-Cotton & Co. report their several state road jobs in Illinois as well started and getting along fine and dandy.

Contractors when in want of labor or work for their outfits write Koenig's Labor Agency, 612 Walnut St., St. Louis, Mo., or 503 Delaware St., Kansas City, Mo.

Walsh Const. Co. got in on a nice steam-shovel job here the other day for the General Motors Co. in the western part of the city. Standard 2 shovel outfits on it.

W. B. Kester of the Middle States Const. Co. has been laid up for a couple of weeks at his home in Peoria, but we are pleased to announce that he is up and around again on their road job in Illinois.

Jerry Connors subbed 150,000 yds. of team work at Union City, Ind., on the Big Four R. R. from the Walsh Const. Co. Jerry has moved part of his outfit that he had on the General Motors Co. job here on to it.

P. J. Murphy, Moberly, Mo., has about 10,000 yd. of work on the Wabash R. R. in the western part of the state to let. Free transportation for men and teams over Wabash R. R. Murphy says this is a fine piece of side borrow work.

A. L. Cook, of Ottawa, Kansas, was awarded the contract for the new line of the Rock Island R. R. in southwestern Oklahoma. He has some nice fresno, borrow and waste work to sublet on this job. Free transportation for labor and outfits over Rock Island Lines.

Contracts have been let for the wrecking of the munition factories of the Laclede Gas Light Co., which were under construction at South Broadway and River Des Peres and near the 6600 block on Manchester avenue, work on which was stopped by the signing of the armistice. More than $5,000,000 had been spent on the buildings and for machinery and other equipment. The salvage from these buildings will be sold to the highest bidder, in accordance with the War Department regulations for the disposition of salvage.

The eighth annual meeting of the National Drainage Congress will be held in St. Louis for three days, beginning Nov. 11th. Representatives of the Chamber of Commerce and the St. Louis Convention and Publicity Bureau met last week to start a movement to have the congress open permanent headquarters here. The convention will discuss measures now before Congress at Washington providing for the reclamation of waste land throughout the country. A considerable portion of land awaiting reclamation is in the Mississippi Valley and it is for this reason that efforts will be made to have the organization maintain its headquarters in St. Louis.

A. B. KOENIG.

Jack for Pulling and Straightening Poles

A jack designed for the express purpose of pulling and straightening poles for telephone, telegraph, electric light, power and railway companies, municipalities and other public utilities having pole equipment, is illustrated. It is claimed that with this jack one or two men can pull the largest pole, whatever the depth, soil or season conditions, in a fraction of the time it takes the usual gang of 5 or 6 men to do the work. Also, one man with this tool is said to be able to straighten a pole in one minute, a job that usually takes several men several minutes to perform. The jack is constructed of the very best materials and along rugged lines, and is stated to be so designed that in both raising and lowering its operations are so perfectly controlled as to insure absolute safety—to pole, overhead lines and other equipment and operator. This tool is known as Simplex No. 328 Pole Jack. It is manufactured by Templeton, Kenly & Co., Ltd., 1020 South Central Ave., Chicago, Ill.

Pulling a Pole With Simplex Pole Jack.

Personals

Colonel Clarence S. Coe of St. Augustine, Fla., who commanded the Seventeenth Railway Engineers in France, has been appointed by the Jugo-Slav republic to take charge of railway construction in that country.

Major W. A. Johnson, assistant engineer on the staff of Colonel Spencer Cosby, United States army engineer in charge of the Galveston district, has been ordered to proceed to Montgomery, Ala., where he will take charge of the Montgomery district.

G. P. Stocker has been appointed head of the department of civil engineering at the University of Arkansas. Professor Stocker received the degree of Bachelor of Science in civil engineering from the University of Wisconsin in 1909. He has taught civil engineering in the A. & M. College of New Mexico, and in Swarthmore College, Swarthmore, Pa. He comes to Arkansas from the Agricultural College of Mississippi, where he was professor of civil engineering.

W. K. Palmer, Kansas City, Mo., who closed his consulting engineering practice in 1917 to enter the army as major of engineers, has organized the Engineering Service Corporation, which has absorbed the business of his former company, the W. K. Palmer Co. The new corporation in addition to carrying on a consulting, designing and supervising engineering practice will undertake the organizing, financing, operating and managing of public utilities and industrial properties. Offices have been opened at 1833 Continental and Commercial Bank Bldg., Chicago, for administrative and business purposes. The operations office will be in Kansas City, Mo., where all engineering work will be done.

Earl Church has been appointed professor of civil engineering, Pennsylvania Military College, Chester, Pa. Prof. Church was graduated from Syracuse University in 1911 with the degree of C. E. For the past eight years he has been engaged in making geodetic and astronomic computations for the United States Coast and Geodetic Survey. As topographer and astronomer with Dr. Hamilton Rice on exploration work in Brazil he assisted in the mapping of some 2,000 miles of the Amazon and the Negros. Prof. Church comes to the Pennsylvania Military College from France after two years of instructing and practical work in all geodetic operations connected with map-making and artillery-fire control. During the past two months he has been engaged in a special study of the application of airplane photography to map-making. Prof. Church has spent four summers as instructor in astronomic work at Columbia University Summer School. He is the author of several pamphlets on astronomic computations for the army.

Industrial Notes

L. E. Strothman, formerly manager of the steam turbine and pumping engine departments of Allis-Chalmers Manufacturing Co., has become vice president and general manager of the Richardson-Phenix Co., Milwaukee, Wis., lubrication engineers and manufacturers of lubricating devices.

The Lidgerwood Mfg. Co., of New York, has opened a branch office in the Hammond Building, Detroit, Mich. R. S. Hutchinson, formerly of the Lidgerwood office in Philadelphia, will have charge of the Detroit office, under the direction of F. B. Knight of the Lidgerwood Chicago office, who previously handled this business in Detroit.

Building and Structural Monthly Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field if subscribed for as a weekly at $3.00 a year; but any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year (or any two monthly issues at $1.50 a year) and the 4 special quarterly issues will be sent without extra charge. Three of these special quarterly issues relate entirely to foreign engineering and construction practice, and the fourth is our annual "New Equipment Issue." The *articles* in the first two issues of each month (1st and 2nd Wednesdays) completely cover the municipal engineering and contracting field. The *articles* in the first and last issues of each month (1st and 4th Wednesdays) completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and last issues of each month (3rd and 4th Wednesdays) completely cover steam and electric railway location, design and construction. See the "mast head" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials

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Errors of Political Legislators and Executives Largely Due to Lack of Adequate Statistics

Correct reasoning about economic matters is impossible without statistical data. No large company is without elaborate accounting systems, not merely because it is necessary to know debits and credits, but because it is necessary to know the efficiency of the management as disclosed by costs and profits. It would seem self-evident that if private companies find it necessary to have statistical data to guide their directors, managers and owners, governments should have similar data for similar reasons. Yet it is notorious that governments, whether county, city, state or national, lack adequate statistical data. In the absence of such information, the most capable mayor or governor is almost helpless in forming policies and in directing their execution.

All the statistical data needed to run a city economically are rarely available. Even worse is the condition that confronts the general manager of a state, the governor. But worse beyond conception is the condition under which the executive manager of the nation—the President—is compelled to operate. As for the statistical matter needed by statesmen in solving the complex problems of economic government, so little is available as to make statesmen objects of pity rather than ridicule, were it not that they are themselves to blame for most of the lack of information.

As an illustration, take the U. S. Bureau of Census, which is the greatest statistical department in the world, measured by the dollars expended in its operation. Once in 10 years it ascertains the number of people also their classification under many heads. What would a business manager think of a statement of the number of the employes of his company by classes were he handed such a statement only once in a decade? Moreover, what would he think of not getting such a statement until five years after it had begun to be compiled? Would he not be filled with a wrath that would lead him to raise heaven and earth to remedy such a condition?

Suppose a business manager occupying the office of President were to ask for an inventory of all the wealth in America, and were told that no such inventory had ever been taken, but that he could be provided with several very good guesses by reliable guessers, whose guesses ranged from 150 to 300 billion dollars! Suppose he inquired as to last year's gross income of all people in America and were told that that also was not much more definitely known than their national wealth.

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

Suppose he asked what the annual increment in national wealth had been last year, and were met with the reply that it had never been even guessed at. What would such a President think of his chance of acting wisely in managing the vastest plant in the world—the consolidated property of the United States of America—without definite knowledge as to the amount of capital invested, the gross annual income, or the annual net savings?

In addition to these major items that any business executive requires at least once a year, there are hundreds of minor items to which reference is made by him or his subordinates every month. For instance, he wishes to know whether a proposed addition to the plant is justified. To ascertain whether or not it is, he must know what the growth of the business has been, what the cost of the addition is estimated to be, what will probably be the gross and net revenues after it is in operation, and sundry other facts. How often does a governmental executive or a legislative body seek such necessary information, or, seeking, gets it? Almost never. Instead, there are acrimonious debates and heated harangues, in which speculations are made to serve for statistics, and guesses for quantitatively deduced conclusions. Such is the present status of political management everywhere, except in relatively few departments in relatively few governments.

Into this morass of managerial ignorance, engineers, here and there, are beginning to enter as executives. Almost without exception they effect improvements, because they are trained analysts of statistical data. Theirs is the analytical profession. Unfortunately, extreme specialization as economic analysts has made most engineers poor psychologists. Hence the difficulty that most engineers experience in securing and holding political positions that are not secured through examination. But the younger generation of engineers, warned by the older generation, is giving more attention to the art and science of controlling men and winning personal support. If they will study practical psychology with as great assiduity as their fathers have studied other applied sciences, the present generation of engineers will be the next generation of political leaders.

Why Municipal Expense and Income Data Are Usually Deceptive

Statistics relative to the cost of running a city are usually given in dollars per annum, subdivided into a few subaccounts. Stated thus they have scant significance to the average citizen. All such statistics should be given in dollars per capita per annum, as well as in other units that are not only comprehensible by the average person, but that can be compared with similar data from other municipalities.

Recently the daily papers published nearly a column of municipal income and expense statistics given out by the U. S. Census Bureau. We venture to say that in the form in which the matter was published very little of it was read and still less was correctly comprehended. To begin with none of it was tabulated, but "run in," which, as every engineer knows, makes it exceedingly difficult to perceive the relative importance of different items. Next, it was nearly all printed in totals and not in unit revenues and costs. The data related to all cities in America whose population exceeds 30,000, the number of which is 227. The total population of these cities is 34,330,000; or about 30 per cent of the entire population of America. About 60 per cent of our population lives in cities, and half of this urban population lives in cities of more than 30,000.

For the fiscal year of 1918 the per capita revenues and expenditures of these 227 cities were as follows:

Revenues:	
Property taxes	$21.03
Liquor taxes	1.04
Other taxes	0.96
Waterworks and other utilities	3.39
Special assessments and special charges for improvements	2.12
Other revenues	4.20
Total	$32.74
Expenditures:	
Expenses of general departments	$20.12
Operating waterworks and other utilities	1.60
Interest on debts	4.34
Total	$26.06
Improvements (paving, etc.)	8.10
Grand total	$34.16

It will be seen that the expenditures exceeded the revenues by $1.42 per capita. The per capita debt was $77.53 (or $1.17 more than for 1917); hence the interest charge averaged 5.6 per cent, which is considerably higher than it is commonly supposed to be.

Of the $3.39 per capita gross revenue from water works and other public utilities, $1.60, or about 47 per cent, was paid out as operating expense. Of this gross revenue $2.63, or 77 per cent, was derived from city waterworks. Since it apparently cost less than half of this $2.63 to operate the city water works plants, there would appear to be a satisfactory profit from the water works; but it is easy to show that this is not so. The investment in the average city water works is about $40 per capita; and 5.6 per cent interest on this $40 would be $2.24 per annum. But the expense of operating the waterworks was about 40 per cent of the gross revenue, or 0.96 per capita, leaving net earnings of $1.67 per capita, or only 4 per cent on the $40 investment.

It is commonly estimated by experienced engineers that a depreciation fund annuity of at least 1.5 per cent on the investment in the average waterworks plant should be set aside in excess of current maintenance expenses. It is also estimated that the annual taxes in the large cities average 2.5 per cent on the actual investment in property. Hence the lost taxes on municipal waterworks (2.5 per cent) plus a moderate depreciation annuity (1.5 per cent) total 4 per cent on the investment, but, as we have shown above, the apparent net earnings were only 4 per cent without deducting a depreciation annuity and lost taxes. Hence, if these deductions were made, nothing at all would be left as interest on the investment in the waterworks plants that serve 34,330,000 people!

In making financial reports of the kind under discussion, the U. S. Bureau of Census frequently comments upon and compares statistical data, but both the comments and the comparisons are usually inadequate and often very misleading. Thus in the report under discussion we read:

> Next to taxes, the source of the largest item of revenue is found in the earnings of public enterprises, which amounted to $116,494,645. This sum is considerably more than double the amount of payments for expenses of public service enterprises, $55,174,480, thus leaving a net revenue of $61,320,165. The bulk of the earnings of public service enterprises came from water supply systems, from which receipts aggregated $90,139,705.

As it stands, without further comment, that paragraph will lead the average reader to infer that municipally operated utilities are very profitable; for when the average man reads that more than half the receipts from the operation of waterworks and other utilities is "profit," he inevitably infers that municipal ownership of public utilities is desirable. As there is no lie more subtle than half truth, so there is no statistical information more deceptive to the average person than that that is incomplete. Of course it will be contended that statistical bureaus should not be blamed for any misinterpretation placed upon the data they publish. But is it not pertinent to ask why such bureaus do not at least make it plain that certain essential data are missing?

There is no real significance in any statement of net earnings unless accompanied by a statement of the investment in the plant that produced them. It is possible, as we have just shown with respect to municipal waterworks, to have a 60 per cent "profit" on an annual income, which turns out to be only 4 per cent on the invested capital. And it is also possible, as we have just proved, for all of this 60 per cent "profit" to be merely a sham profit, since part of it should be set aside to cover depreciation, and the rest to make good the taxes that would have been paid to the cities had the waterworks been privately owned.

It seems to us that engineering societies should endeavor to teach public officials not only how to present municipal data in a form that admits of comparisons, but how to interpret the significance of the data to the public. So long as the public votes on economic measures, surely every effort should be made to teach the public the significance of statistical data. Unquestionably municipal accountants do not intentionally deceive the public, but the public is usually self-deceived, if it has any conception at all, as to the published accounting summaries.

Josh Billings said: "Figgers won't lie, but liars will figger." It would be more correct, if not so funny, to paraphrase him by saying: Figures won't lie, but incompetents will figure. Hence the desirability of making it difficult for incompetent figurers to go astray.

Freezing a Nation Into Submission

A strike order has been issued calling upon 600,000 bituminous coal miners to quit work Nov. 1 unless their demands are granted. All they ask is a six-hour day and a five-day week at present weekly wage rates. All they threaten is a heatless winter if what they ask is refused. No, that is not quite all they threaten; in addition, they threaten taking away the steam power that operates the factories and electric and steam railways, electric light and gas plants, and the like.

Three years ago a somewhat similar threat was made by the railway unions, when they demanded a 25 per cent increase in wages under the guise of an 8-hour day. The threat was effective. The Adamson bill was passed and signed by the President. Doubtless the railway employes were entitled to the increase in the wages that they then demanded, but their method of securing the increase was a vicious method, for it was tantamount to a threat of starvation to dwellers in cities unless their demands were granted. Emboldened by the success of that threat, the soft coal miners are now about to use the same sort of a threat. We believe, however, that they have failed to make proper allowance for the difference both in conditions and in public sentiment three years ago and today.

Three years ago we were menaced by war, today we are not. The railway employes three years ago were underpaid. The coal miners today are not underpaid. Three years ago many congressmen were afraid they might fail of re-election were they to pass a bill prohibiting strikes on railways. Today they realize that the great majority of the voters are in favor of such a bill, and it is now practically certain that the strike provision in the Cummins bill, perhaps in modified form, will be enacted into law. In short, the coal miners' strike bludgeon is being waved in the face of a nation that is angry clear through at the threat, whereas the strike bludgeon that the railway unions waved three years ago only served to start an anger that had in it at first more of surprise than of deep seated resentment.

While congressional committees are engaged in drafting a strike clause for the proposed railway control law, the coal miners are preparing to give the eastern and middle states the bitterest dose that they have ever swallowed. We haven't the slightest doubt as to what the patient will do after he has been forced to swallow a few bottles of that dose. He is going to get up and beat the doser into, not insensibility, but sensibility. He is going to force congress to pass antistrike laws that will protect him from such vicious attacks as the one now about to be made upon him by the soft coal miners' union.

The Chicago Tribune put this whole matter very clearly in one paragraph:

> Mr. Gompers recently has asserted that the Cummins railroad bill would enslave workers by denying them the fundamental right of striking. He fails to reflect, we think, that there is another right involved: the right of the sovereign people to maintain the integrity of industries absolutely essential to life itself.

Where a relatively small number of workers render a service that is vital to the economic welfare of a large number of people, it is scarcely conceivable that the smaller number shall be free at any time to bring misery and even death upon the larger number. Yet we have reached the stage in economic and social evolution when the smaller number actually has the hardihood to assert its right to starve or freeze the larger number into submission! It is true that the smaller number (the 600,000 coal miners in this case) tries to make it appear that their fight is not with the public but with the mine owners. This is mere camouflage. Who, in the last analysis, is going to pay the increased price of coal if the coal miners win the fight for a week of 30 working hours? Obviously the public. So the final cost of the reduced weekly productiveness of the miners is to be assessed against the very people whom they disclaim having a fight against—the public.

This conflict over "the freedom to strike" is an inevitable conflict. Congress will merely delay the issue and intensify the misery if it does not meet the issue courageously now. Congressmen would be more than human if they did not count the number of votes that will be influenced by their decision as to the "freedom to strike." Relatively few congressmen, however, need worry over antagonizing all the labor union votes in America, for the entire number of unionized workers totals only 4,500,000 Samuel Gompers said the other day

> In the American Federation of Labor we have unions which in total number nearly 4,000,000 members. The four brotherhoods represent 500,000. That means approximately 4,500,000. But that is not 10 per cent of the population it is less than 5 per cent
>
> The fact which is usually overlooked is that nearly every one of these 1,500,000 people has a wife and children, and counting the American quota as usually presented, five to a family, these 4,500,000 represent about 21,000,000 people, or, in other words, very nearly a quarter of the population of the United States

Doubtless Mr. Gompers is approximately correct in his statement that there are 1,500,000 workers in all the unions But it can easily be shown that his estimate that 24,000,000 people belong to the families of those union men is grossly erroneous. There are approximately 34,000,000 workers of all classes in America, or about one worker to every 3.3 people If, then, we multiply the 1,500,000 union workers by 3.3, we have 14,850,000 people that are members of the families of union workers, or about one person in eight of our total population, instead of the one in four claimed by Mr. Gompers His error arose from his confusing the word "worker" with the word "head of a family." There are about five persons to a family, but the average family has about one and a half workers.

Mr. Gompers tacitly assumes that the entire 4,500,000 union workers will fight for the "freedom to strike." While he may be correct in this assumption, he overlooks the fact that not one-third of these union men are engaged on public utilities (including railways) and in coal mines—the two great classes upon which the public is vitally dependent. Hence if congress were to prohibit strikes only by members of those two classes of workers, the prohibition would not directly affect the "freedom" of more than one-third of the 4,500,000 union workers These 1,500,000 union men thus affected are members of families totaling only 5,000,000 people. So, looked at purely from a vote getting point of view, very few congressmen need worry about continuing to hold their jobs if they vote according to their convictions as to what restriction should be placed upon "the freedom to strike."

The prehistoric freedom to carry weapons has been taken away from all Americans not specially privileged. If society can thus restrict one class of freedom, it can restrict other classes. Unless we misinterpret the temper of the American people, we are about to witness a disarming of certain strike-toting unions that will be analogous to the disarming of gun toting individuals throughout the country shortly after the civil war.

Likes Engineering and Contracting's Editorials

To the Editor: For a number of years I have had the pleasure of reading Engineering and Contracting, and have been particularly interested in the editorials. I have the opportunity of reading a number of engineering magazines, and with all due respect to the various periodicals, I consider the editorials in your magazine most able, clear and effective. I congratulate you upon the character of the editorials presented.

SYLVESTER Q. CANNON,
Salt Lake City, Utah. City Engineer

A Good Suggestion

To the Editor: Among the many technical magazines that come to my desk, there are none whose editorials satisfy my taste for logical thinking so well as those of Engineering and Contracting. I thoroughly appreciate the value of correct definitions to start with. It occurs to me, anent your article on the definition of "engineering" in the Oct. 8 issue, that inasmuch as "production" includes all acts of "service" to a "consumer," Mr. Gillette's definition might be further clarified by using the word "service" instead of "production," making it read: "Engineering is the systematic application of science to the problems of economic service." What think you?

Cleveland, O. FRED SCHULDER.

[Mr. Schulder suggests an excellent change in Mr. Gillette's definition, because the word "service" is now commonly regarded as broader than the word "production."—Editor.]

Book Reviews

Timber: Its Strength, Seasoning and Grading.—By Harold S. Betts, M. E., Forest Service, U. S. Department of Agriculture. New York: McGraw-Hill Book Co., Inc. London: Hill Publishing Co., Ltd. Cloth; 6x9 in.; pp. 234; illustrated.

Reviewed by J. C. PENN.

Associate Professor of Civil Engineering, Armour Institute of Technology.

Bulletins, papers, circulars of the U. S. Department of Agriculture, the Forest Service in connection with it, the Forest Products Laboratory, the office of the Industrial Investigations, the various lumbermen's associations, all contain very valuable data, but until such data are classified and boiled down and presented between the covers of one book, they are practically useless and merely occupy valuable space in libraries. Mr. Beggs seems to have solved the problem of assimilation very thoroughly.

A short chapter is devoted to the timber resources of this country, and with pleasure we read that, "long before the present enormous forest resources are eaten up, it is more than probable that readjusting economic conditions . . . will reduce the annual drain to an amount not more than the amount of growth."

Chapter II consists principally of a table classifying the woods as to weight, shrinkage and strengths, both in actual figures, and as compared with Hendricks county, Indiana, white oak. The methods by which the various strength factors have been determined are well explained and illustrated. The 17 pages of Chapter III are devoted to effects of moisture.

The characteristics effecting the strength of structural timbers, density, rate of growth, direction of grain, moisture, sapwood, defects, etc., are taken up in detail. The causes of decay are well illustrated. Grading and classification of defects and working stresses are dealt with at length.

Strength tests of telephone posts, cross arms, packing boxes, vehicle parts, cultivator poles, should be of great interest to the manufacturer. Some 36 pages are given over to this.

Chapter V deals with the seasoning of timber. A chapter on grading of lumber by manufacturers' associations and a chapter on the quantity of lumber produced and used in the United States finishes the book.

Structural Engineers' Handbook: Data for the Design and Construction of Steel Bridges and Buildings.—By Milo S. Ketchum, C. E., M. Am. Soc. C. E., Dean of the College of Engineering, and Professor of Civil Engineering, University of Colorado, Consulting Engineer. Second Edition. New York: McGraw-Hill Book Co., Inc. Flexible cover; 6x9 in.; pp. 896.

Reviewed by JOHN C. PENN,

Associate Professor of Civil Engineering, Armour Institute of Technology.

Ketchum's Structural Handbook is almost a necessity for the structural designer and it is to be regretted that the author was not able to carry out the thorough revision which he had planned. His war duties as Assistant Director in charge of construction, U. S. Government Explosives Plant at Nitro, W. Va., prevented any other than the ordinary correction of errors and addition of data for the new edition.

Sixteen pages were added to Chapter I, illustrating standard details for steel windows and doors giving data on cement and gypsum, tile roofs and methods of determining stresses in mill building columns and in rigid frames.

The chapter on highway bridges has been rewritten and enlarged by an addition of 16 pages. The bridge standards of the Wisconsin and Iowa State Highway Commissions have been included. The addition of tests on floor-slabs, a discussion of the distribution of concentrated loads on floor stringers, tables and diagrams useful in design of floors for various motor truck loads, standard details, all help towards making this good mine of information on steel designing a better one.

"The book is a source book and is not a treatise, and is intended to furnish data and detail that are available only to a few engineers, and standard specifications for materials and workmanship that are available only in transactions of societies and special treatises."

The actual scope of the work is best shown by the chapter titles, as follows:

Chapter I. Steel Roof Trusses and Mill Buildings, 68 pages.
Chapter II. Steel Office Buildings, 28 pages.
Chapter III. Steel Highway Bridges, 40 pages.
Chapter IV. Steel Railway Bridges, 75 pages.
Chapter V. Retaining Walls, 19 pages.
Chapter VI. Bridge Abutments and Piers, 31 pages.
Chapter VII. Timber Bridges and Trestles, 22 pages.
Chapter VIII. Steel Bins, 19 pages.
Chapter IX. Steel Grain Elevators, 19 pages.
Chapter X. Steel Head Frames and Coal Tipples, 24 pages.
Chapter XI. Steel Standpipes and Elevated Tanks on Towers, 22 pages.
Chapter XII. Structural Drafting, 34 pages.
Chapter XIII. Estimates of Structural Steel, 15 pages.
Chapter XIV. Erection of Structural Steel, 44 pages.
Chapter XV. Engineering Materials, 35 pages.
Chapter XVI. Structural Mechanics, 38 pages.
Chapter XVII. The Design of Steel Details, 27 pages, and 165 structural tables, covering 272 pages.

Each chapter is followed by a set of specifications suitable for the structure under discussion and by a list of references.

The chapter on estimates of structural steel contains considerable information on costs of material, fabricating, drafting, mill extras, shop labor, shop costs, etc. They are of the year 1914 and earlier, however; in fact, the cost of drafting is given for 1907; and in very many cases no dates are given. Under cost of erection, a quotation is given without date or place. Information of this nature without full details is, to say the least, very misleading.

Applied Mechanics.—By Charles E. Fuller, S. B., and William A. Johnston, S. B., Professors of Theoretical and Applied Mechanics, Massachusetts Institute of Technology. Vol. II, Strength of Materials. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. Cloth; 6x9 in.; pp. 556; illustrated.

Reviewed by JOHN C. PENN,

Associate Professor of Civil Engineering, Armour Institute of Technology.

"As preparation the student should have a knowledge of differential and integral calculus, the principles of statics and dynamics, and the methods of determining the centers of gravity and moments of inertia of areas and solids." So states the preface, and indeed, this is a test on strength of materials that contains nothing on center of gravity and moments of inertia as such, and no mere smattering of calculus will do to read and understand this book. I surely would like to have the opinion of an average college student, no matter if a senior, as to the merits of this text. He would judge it, of course, by the solid pages of mathematics.

The first chapter contains a thorough discussion on the physical properties of materials, but it is mere discussion, the actual properties, the results of tests are not given. Stress and strain, including the entire theory of the ellipse of stress, follows in the next chaper. Chapter III, some 20 pages, is devoted to uniform stress and uniformly varying stress, and contains axial tension and compression, thin hollow cylinders, thin hollow spheres and riveted joints. Friction in riveted joints, the behavior of riveted joints under test, tables giving the shearing and bearing values of rivets are not given. In fact not a single numercial value is mentioned under any head in this chapter.

Stresses on beams occupy a rather long chapter, as they should. No reference to a "Carnegie Pocket Companion" or any standard shape of steel section or strength of timber is mentioned. Deflection and continuous beams and combined loading follow. Then a chapter on the general theory of flexure is inserted.

The chapter on columns seems out of its natural order, but on the whole is good. Shafting, springs, curved bars, circular rings, hooks and links, occupy many pages. A chapter on arches and catenaries, although short, is inserted. Cylinders and plates, tubes and thick hollow cylinders are explained in a manner that worries any mathematician. Concrete has a very short space at the end of the book.

The problems at the end of each chapter are numerous, and as a whole good. Safe loads, allowed stresses, etc., are enumerated under each problem, without stating any authority; nowhere else in the text do they appear, and in the problems they are not always the commonly allowed figures.

The preface says that, in a brief course parts of Chapters II, III, IV, V, VII, IX, and X, and the whole of Chapters VI and XI to XIV, inclusive, may be omitted. With this help and with the help of supplementary lectures on tests of materials, this book might make a good text book on strength of materials.

For the practicing engineer who wants figures, it promises little. Yet, as a reference book in which all phases of a particular problem in strength of materials is analyzed to a last detail, it should have a real place in an engineer's library.

Proper Methods of Applying Roofing on a Gypsum Roof Deck

By CURTIS F. COLUMBIA,
Industrial Engineer, New York.

There are no available statistics to determine, even as an approximate figure, the total amount of roof area constructed of gypsum during the past 15 years; but it is safe to say that the great number of installations are tremendously significant and conclusively prove that the leading engineers and architects throughout this country are recognizing the peculiar value of gypsum and are realizing its particular adaptability for the roof decks of factories, machine shops, power plants, chemical works, paper mills and all other types of industrial buildings as well as certain types of commercial buildings.

This popularity is directly due to the fact that gypsum when moulded into the form of slabs or tile is perhaps the best known material for fire protection as well as possessing that valuable asset of lightness which cannot be found in other roof deck materials. Gypsum weighs 50 per cent less than concrete, thereby making a considerable saving in the steel framework necessary to sustain the required loads. The large units are quickly erected and may be placed during freezing weather. Gypsum is not disintegrated by acid fumes which is a decided factor when the problem of a roof deck presents itself for the construction of gas work buildings, railway roundhouses and chemical plants.

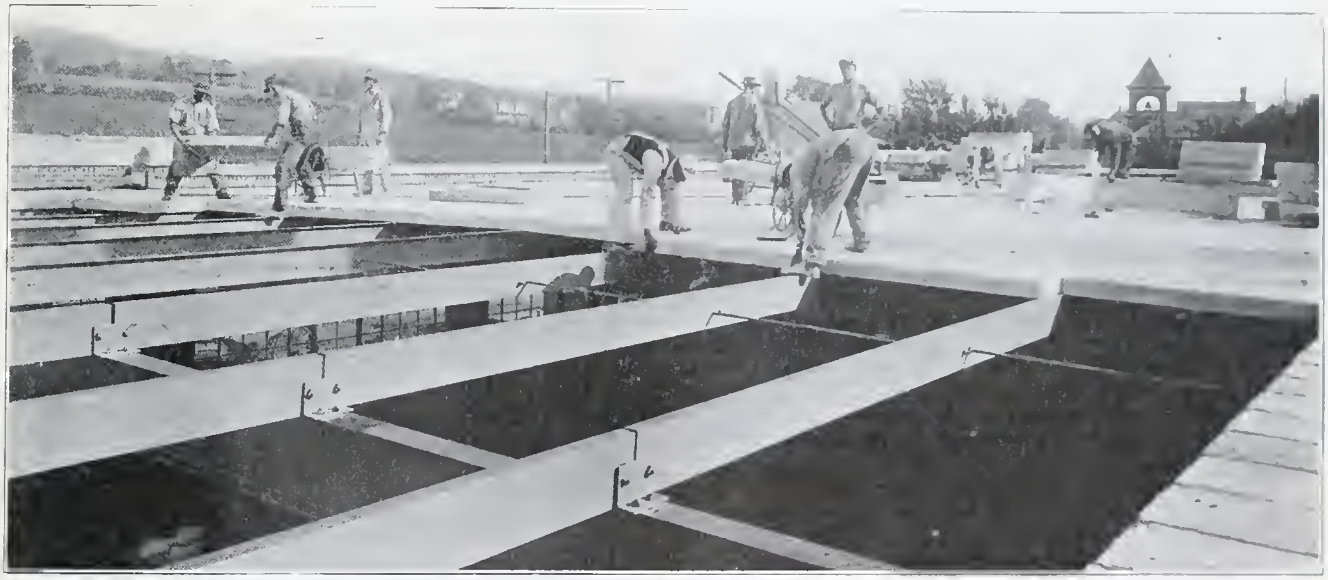


Fig. 1—Gypsum Precast Tile Being Laid Directly on Purlins, No Sub-purlins Necessary.

Furthermore, the fact that gypsum transmits so little heat makes a roof deck which is free from condensation and the annoying and costly "drip" which always accompanies the presence of moisture when it is permitted to collect on the under side of the roof. This moisture penetrates the roof deck and rots the roof covering in a very limited time, causing leaks and in time total disintegration. With a gypsum roof deck this cannot occur.

In view of the advantages of gypsum and believing that there is sufficient evidence that the gypsum roof has come to stay and will increase in popularity, the following data have been compiled with reference to the materials and methods of applying various roof coverings. First, however, it is necessary to briefly outline the construction of the finished roof deck.

There are two generally accepted types of gypsum roof deck, "poured roof" and "precast tile." Each has its advantages. The poured in place roof is a somewhat unique construction in which steel cables are suspended from truss to truss, and are imbedded in a slab of gypsum which is poured on the job, the cables taking up the full roof load. The precast tile are manufactured in definite sizes and shipped to the building site ready for immediate erection. The gypsum tile, however, is generally accepted as the most economical as well as presenting certain distinct advantages. There is no form work required in the placing of the tile which makes it an ideal method for re-roofing as the construction work can proceed without interference with plant operation.

The tile are placed in units as shown in Fig. 1 without mortar. The joints between the tile are then grouted with gypsum grout consisting of 1 part unfibred cement gypsum plaster and 3 parts of clean sharp sand. As each tile is individually machine moulded the surface of the roof is practically uniformly smooth and there is no possibility of uneven surfaces tearing or cutting the roof covering. Curbs under monitor or sawtooth sash, and end walls of monitors or saw teeth are constructed of 3-in. solid gypsum tile. The illustration shown in Fig. 2 shows the use of "gutter fill" which is composed of gypsum and wood chips and is a substitute for concrete fill. When the tile, end walls and gutter fill are in place the roof covering may be applied immediately.

This roof covering may be any one of the various forms, but when baked tile, slate, or Ludowici tile are to be applied, an extra dense thick nailing deck should be specified. Cut nails or barbed slater's nails are used having at least 1½-in. penetration into the gypsum deck. No nailing strips are required as in concrete roofs. This is particularly advantageous on steep roofs, as the roof covering not only can be anchored to the gypsum tile by means of hot asphalt cement, but can also be attached by means of nails. This is something that has been a great drawback to roofers when applying the covering over concrete because almost always no provision is made for nailing strips of wood on which to anchor the covering at various places in order to relieve the strain. With gypsum tile, however, into which nails can be driven securely the necessity of inserting nailing strips every 20 ft. is eliminated.

There are certain considerations which should influence the selection of the most suitable type of roof covering. These considerations may be classified according to their importance.

(a) Probable life which includes a number of factors, namely, damage by natural elements, and damage by peculiar conditions, depending on the processes of the plant, such as presence of alkali or acid.

(b) Chance of leakage.

(c) Resistance to fire.

(d) Cost, which not only includes the original outlay, but maintenance.

The character of the roof deck should in every case determine the character of the weatherproof covering to be applied to it; and vice versa, if the architectural requirements of appearance, service, resistance to fire are considered, then the roof deck must be such that it will satisfactorily receive and support the selected covering, and such that the union of the roof deck, with the roof covering, will constitute a completed roof fulfilling the requirements of life, service and appearance.

It must be remembered that when a built-up roof covering is laid on a flat concrete roof slab the movement at expansion joints seems to demand the use of a membranous covering possessing tensile strength and ductility. No roof covering possesses these two qualities to a sufficient degree to eliminate the development of cracks causing leaks. Their ductility is affected by temperature, increasing with rising temperature until the melting point is reached, and decreasing with falling temperature, until they become brittle.

The structural character of the intersections of roofs with vertical surfaces, such as end walls, is often overlooked and leaks will occur if there is the slightest likelihood of movement between the horizontal and vertical structure. The most favorable condition exists when the roof and vertical structure are locked together or are practically monolithic.

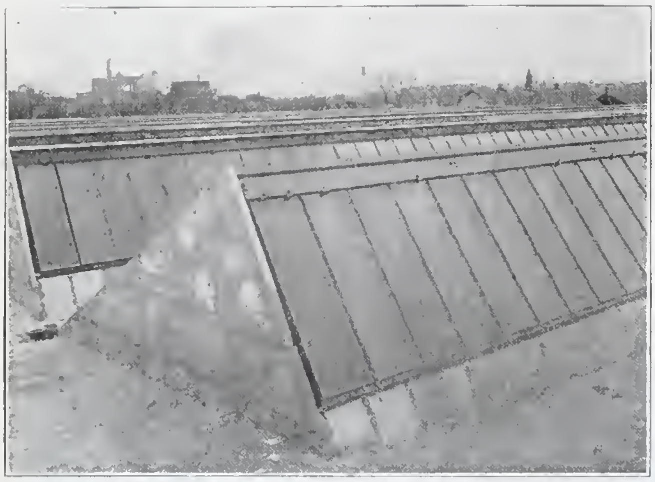


Fig. 2—Showing Gutter Fill and End Walls of Gypsum.

Slate should not be used on a pitch less than ¼ and preferably not less than ⅓, and if this latter pitch is used the slate should be laid in elastic cement, since water is likely to be blown up under the slate in driving rain storms. The lap of the slate should be greater for the lower pitch. For good construction, there should in all cases be a layer of felt paper between the slate and the gypsum deck.

Hard burned clay or terra cotta roofing tiles, Fig. 3, are made in many forms and sizes among which are plain tile, book tile, Spanish tile, pan tile and Ludowici tile. The standard color of tile roofs is terra cotta red, but they are also made in varying shades and glazes.

Crown, ridge, hip and valley-tiles are semi-cylindrical, or segments of cylinders, used for the purpose indicated by the name.

Tiles should be well burned and be free from fire-checks, cracks, blisters and flaws. The tiles should have a glazed exposed surface to prevent absorption of water and consequent crack. Plain roofing tiles are usually made ⅝ in. in thickness, 10½ in. long, and 6¼ in. wide. They weigh from 2 to 2½ lb. each, and expose one-half to the weather. Plain tiles are also made with grooves and fillets on the edges, so that they are laid without overlapping very far. Interlocking tiles weigh from 8 to 12 lb. per square foot. The lighter weight tile are most adaptable to gypsum roofs.

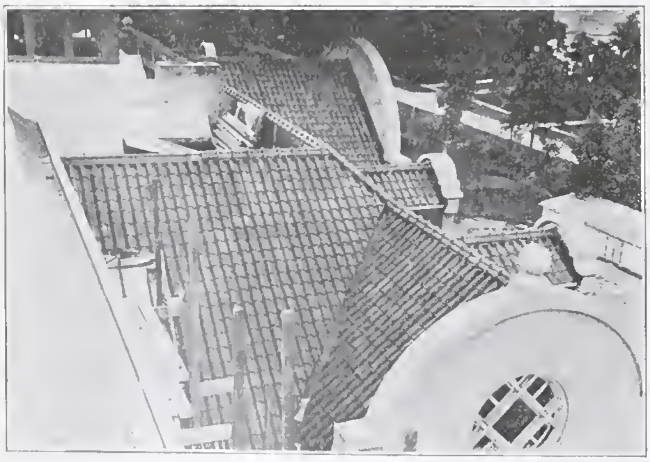


Fig. 3—Terra Cotta Applied Directly to the Tile.

The most common method of applying tile roofings is to cover the gypsum roof deck with asphalt roofing felt or horizontal strips of wood 1 in. high by 2 in. wide spaced to suit the size of the tile nailed to vertically laid battens nailed to the roof. The tile are then fastened to the horizontal strips with No. 12 gage copper wires from pierced lugs at the lower end of tiles. The tile have interlocking side joints and the horizontal joints are laid in elastic roofing cement of the same color as the tiles.

Tin or copper sheets may be used on a gypsum roof of any slope if the joints are properly soldered (see Fig. 4). It is seldom used, however, except for pent house roofs on apartment and hotel buildings where the area is comparatively small. The layers of felt paper serving as a cushion may be eliminated. The tin is nailed to the roof deck with 4d slating nails, which have a broader head than a common nail.

For small buildings or on such buildings where clay tile roofs are not the most desirable or economical on account of features of design, and where the pitch exceeds ⅓, asbestos shingles make an excellent roofing. Laid in the "French" or diagonal method they present a fine appearance and being furnished in several colors are suitable for use on residences, mansard roofs, etc.

Asbestos shingles are made of asbestos fibre and Portland cement under pressure and are applied to the gypsum by first covering the deck with 1-ply slater's felt and then nailing down the shingles with copper nails or clenchers like ordinary shingles, or in diagonal or "French" fashion.

Tar and gravel roofs (Fig. 5) and composition roofs (Figs. 6 and 7) are applied by spreading upon the gypsum roof deck three or more courses of tarred felt weighing from 14 to 15 lb. per 100 sq. ft. for each course, which is then coated with an even layer of hot straight run coal tar pitch, the amount of which for each 100 sq. ft. should be from 100 to 120 lb. It is seldom necessary to nail the felt to the gypsum deck as the material adheres perfectly. While the last coat of pitch is hot it is covered with screened slag or gravel, the amount used being about 300 lb. per 100 sq. ft. Nailing may be done where found necessary, but care should be taken that each nail is covered by at least two plies of felt.

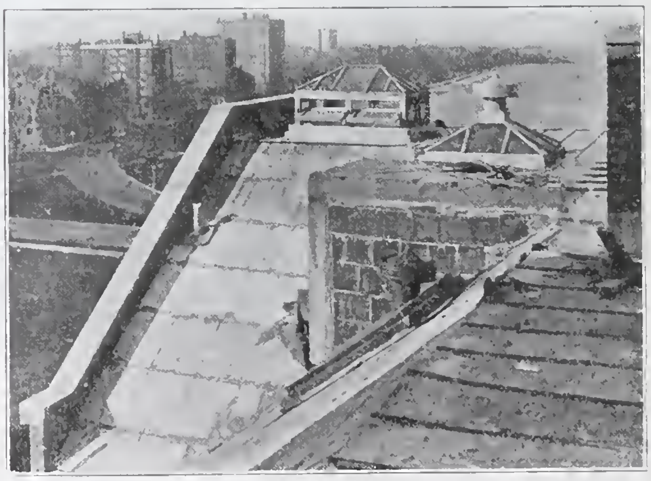


Fig. 4—Tin and Copper Are Easily Applied to Gypsum.

Requirements for application of felt and pitch on gypsum poured decks is the same as that for concrete, except that the felt shall be nailed directly to the gypsum deck. The gypsum should be thoroughly dry when the pitch is applied.

Requirements for gypsum precast slab are the same as the requirements of roof covering over wood sheathing, with the exception that the rosin sized sheathing or unsaturated felt may be omitted First two plies of felt should be nailed sufficiently to hold them in place and to prevent wrinkling or tearing of the felt. The last ply of felt should be nailed approximately 6 in from the upper end of each sheet, nails should be spaced not more than 2 ft. apart, and not to exceed ⅞ in. in length and shall be driven through flat tin discs 1 in. in diameter.

In the preparation of the surface of the gypsum deck, for the application of asphalt roofing, care should be taken to see that all sharp angles are filled so that the roofing material need not be bent to a radius of less than 6 in. On steep surfaces for flashing and anchoring the roofing at the eaves, provision should be made for anchoring roofing sheets with suitable anchor strip. The surface must be thoroughly dry and swept clean before the roofing is applied, and the deck should first be covered with a standard primer thoroughly brushed in.

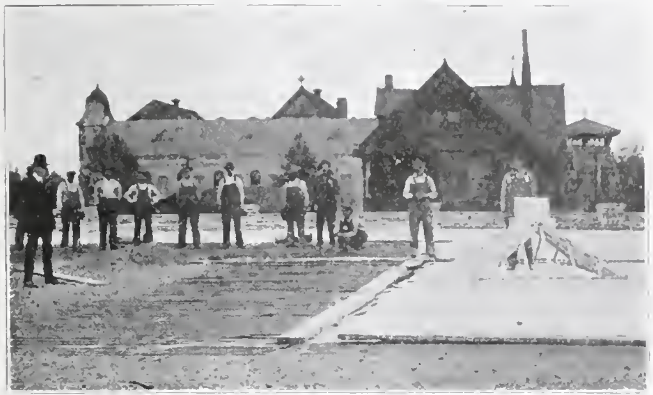


Fig. 5—Tar and Gravel Roofing.

Care should be taken in the use of a primer as certain primers cannot be used with tar or asphalt with any degree of safety. Any good primer made of straight asphaltum cut with a good solvent such as benzole to a liquid form so that it can be brushed on, is usually satisfactory.

Another point which must be considered is that the gypsum tile must be entirely dry before the application of the primer. In many cases the hot asphalt applied would penetrate the surface, and the result would be—all of the advantages that are found in a priming coat, and accomplished in one operation. In this case the joints of the tile should be waterproofed with a very small amount of bituminous primer. One man with a long-handled brush could waterproof the joints on more than 100 squares of roof in one day.

Asphalt paint free from coal tar is often used as a primer, and reduced to proper consistency with petroleum naphtha so as to permit heat penetration.

In other cases the same primer is used as for concrete decks, which consists of a material having an asphalt base, and which is absolutely the best combination of materials which we know of for this purpose. In this case the primer should have at least 24 hours to dry.

The only purpose of priming is so that there may be an actual bond between the fabric and the gypsum deck, said to help hold the roof covering in place when the covering does not have sufficient weight to resist weight suction from above, or with pressure from underneath. In nailing into gypsum there is some question as to the resistance when the strain is exerted perpendicularly with the nail, but in case the strain is exerted in any other direction nailing apparently serves the same purpose as it would be in a wood deck.

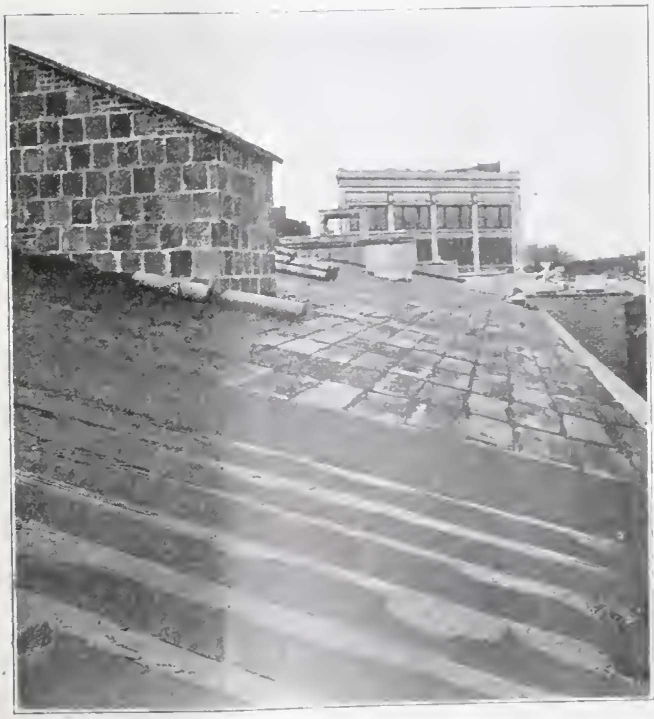


Fig. 6—Composition Roofing Applied Over the Primed Surface.

In dealing with the matter of the proper roof covering for gypsum roof tile, it is not only necessary to give consideration to the roof deck proper, but the building itself and the purposes for which it is intended should be taken into account.

Buildings on piers where boats are stored, especially boats of any size, are subjected to a distributing transverse or sidewise motion due to shocks coming against the pier. This tends to break or disintegrate roof decks such as concrete slab; therefore it would not be desirable to use a concrete slab roof deck or other similar material for a building of this kind. Since the buildings are of fireproof nature it would not be best engineering practice to employ a wood roof deck. Therefore at this point gypsum is most common.

Thus gypsum as a deck construction is economical as it does away with many of the difficulties found in other types of roof deck. Gypsum tile may be used for any pitch and are adaptable for comparatively any type of roof covering.

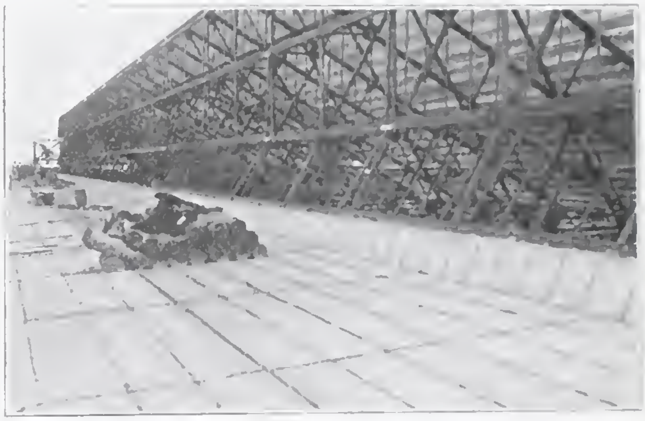


Fig. 7—Roof Deck Before Applying Primer.

Demolishing an Old Stone Building With Dynamite

An old 2½-story stone house, Mendenhall, Pa., was successfully torn down with dynamite. The house was constructed in revolutionary days and was very solidly built. The walls were 20 in. thick. The window and door casings and floors were of oak and the beams were massive hardwood timbers. Conforming with the old style of construction, the house was built around a large chimney connecting with open fireplaces in the parlor, dining-room and two of the bed rooms. This chimney and the fireplaces were also built of stone. The method of blasting down the structure was as follows: With a pointed steel bar and sledge, holes were put down in the ground all around the house about 1 ft. from the foundation walls and to a depth of about 2 ft. A half cartridge of dynamite was exploded in the bottom of each hole to form a cavity into which a larger charge of dynamite could be loaded. Twelve and a half pounds of 40 per cent ammonia dynamite were loaded in each of these cavities and tightly tamped in with moist soil. There were 20 of these holes. They were spaced about 3 to 4 ft. apart. Twenty-five pounds of dynamite were laid on the parlor floor in the corner of the building and covered with about 50 lb. of moist earth and 25 lb. more were laid on the floor of the fireplace in the dining-room, also covered with about 50 lb. of moist earth. An electric blasting cap was inserted in each charge. The various charges were then connected in series so that there was a complete circuit of all of the loads both inside and outside of the building. As stone has a tendency to fly a long distance through the air when propelled by heavy charges of dynamite, 750 ft. of leading wire were used to connect the charges with the blasting machine which was operated by a blaster from the shelter of an old spring house.

Safety Measures for Preventing Accidents in Steel Erection

Steel erection presents, in general, the same problems regarding safety encountered in other field construction work. Like other outside construction work, it is done under more difficult conditions than shop work for the reason that the conditions are varied and constantly changing, while in the shop many conditions affecting accidents are fixed. The weather plays a much more important part in the field than in the shop. The force of workmen is much less stable in the field than in the shop. With the field force constantly changing, it is much more difficult to educate the men to safety and to avoid getting men who are actually unsafe on the work. There are, however, certain differences between steel erection and general construction. In steel erection the leads are generally much heavier and are handled under more varying conditions at a greater distance from the ground. There is an element of risk in every lift. While the derrick may have been tested throughout and proven safe, an accident may be caused by a bridgeman making one careless hitch on a load of beams. In a paper presented Oct. 1 before the Construction Section of the 8th Annual Safety Congress of the National Safety Council, Col. E. A. Gibbs, General Manager McClintic-Marshall Co., described the measures taken by his company for the prevention of accidents in steel erection. His paper practically in full follows:

The appliances for erecting steelwork have developed and increased greatly during the past 20 years, and erection is relatively much more safe. Nevertheless, many new difficulties have arisen. The average weight of pieces to be handled has greatly increased while certain limiting features have remained unchanged, such as track clearances and gage. A girder may increase in weight, but the derrick car that handles it must run on, and be supported by, the same track as previously. This increased weight has had one benefit. Heavy members cannot be juggled and handled in any manner that the foreman desires. The equipment can be designed to handle these in only a few ways, and the foreman must be governed accordingly. Therefore, the work is likely done as the design of the equipment contemplates and with corresponding safety.

Causes of Accidents—Real accidents are those which occur through no neglect on the part of the workmen or the employer, which we might reasonably expect to be foreseen and prevented. Preventable accidents are those which could have been avoided, had either the men or others in authority over them exercised the proper amount of vigilance. It is conceded that well over half of all accidents are preventable and the proportion is probably higher.

Preventable accidents may be divided into three classes:

1. Accidents due to workmen themselves: by reason of being physically incapacitated, ignorant, inexperienced, intemperate, careless or reckless, acting the fool, or actual disobedience.

2. Accidents due to foremen: improper selection of men placed in charge of work or doing the work. Inadequate instruction to workmen. Putting men or allowing them to go into dangerous places unnecessarily. Lack of vigilance and orderliness on the work. Failure to investigate questions of safety made by workmen.

3. Accidents due to superiors: by reason of improper selection of foremen, safeguards, equipment for doing the work and instructions regarding its use.

It is believed that the greatest difficulty is with the men themselves. Construction companies have recognized the necessity of having proper equipment, and that phase of the situation is in relatively good shape.

The foremen, while still skeptical as to the value of certain expedients for safety, can be educated more easily as they form a small class, and as their tenure of employment depends upon the results they produce, it isn't hard to impress them with the effect of accidents on their work. It isn't so easy to get them to enforce safety methods. The conditions on a job are changing rapidly and the foreman is crowded to make time. He cannot do everything and naturally devotes his time to things that speed the work and affect the direct cost. Only constant pressure on the question of safety, and using every accident to point out the neglect of foremen or men will bring results.

Instructions and Cautions for Bridgemen.—The workmen are by nature and training a daring class of men and instinctively feel that their courage and skill are questioned when they are asked to comply with many of the expedients for safety. However, they can and must be educated to take proper precautions to protect themselves and their fellow-workmen. Bulletins, notices and placards of various kinds containing written and illustrated cautions and effects of neglect are very good. Our company in 1910 issued a book to its foremen containing instructions and cautions for the prevention of accidents. We also started at that time to post a bulletin with certain of the most common faults of workmen and how to avoid them. A small copy of this bulletin is handed to each bridgeman whom we employ. It contains several short paragraphs as follows:

Don't be Reckless.—More accidents occur through recklessness than any other cause. Don't walk on rods. Don't ride a load. Don't ride on a locomotive crane.

Don't be Careless.—Look where you step, and be sure that on what you step is safe and secure. Don't step on ends of loose plank. Don't start to slide down a line unless you are sure the ends are fastened.

Be Orderly.—Do whatever you do in an orderly, careful manner. Pile material so that it cannot roll, fall, tumble, or be blown over. Don't let tools or equipment such as bolts, nuts, drift pins, blocks, dolly bars, etc., lie around so that they can be knocked off the work or so that anyone can fall over them.

Unfit Condition.—Don't go to work if you have been drinking or do not feel well. If you are lame or have any defect in hearing or eyesight, you should not work at this business, as by so doing you endanger your own and fellow workmen's lives. If you are inexperienced in or unsuited for the work to be done, don't undertake it.

Be Viligant, Watch What You Are Doing.—Don't stand or work under a load. Don't go in the bight of a line nor stand in front of a snatch block. Don't work on or about a crane runway when the crane is in use unless there is a step between you and the crane.

Don't Use Unfit Tools.—Be sure the tools and equipment you use are in good working order. If they are not, don't use them.

Don't work with men who don't observe these rules.

Proper Erection Equipment First Requirement for Safety.—The first requirement for safety in erection is to have the proper equipment. Foremen and workmen cannot be expected to take the necessary precaution if they are not provided with proper equipment in first-class condition. And it is not enough to provide first-class equipment. It must be kept in good condition by constant attention on the job and by overhauling at the completion of the job if necessary.

Some of the principles observed by our company regarding equipment are:

Use no wooden travelers or derricks, except very light derricks and jinnywinks.

All castings in erection equipment under heavy stress to be made of steel. We make all of our sheaves for cable blocks, except small blocks for ⅝-in. cable, of steel. All castings when bending strains are encountered are made of vanadium steel. Vanadium insures a more uniform casting and tends to eliminate blow holes.

Forgings of importance, such as the headblock of a derrick car, are made of nickel steel.

Use the very best manila lines.

Use cable slings, instead of chains. Very important.

Automatic brakes in addition to mechanical brakes on all electric hoists.

In the erection of ordinary work the equipment provided, if it is of the best quality, is amply strong for the purpose. It simply requires proper handling and reasonable care.

For the heavier classes of work, heavy and frequently special equipment must be used. This equipment requires good designing and the best materials. Good designing implies a thorough knowledge of how the equipment is to be used, and the provision for all reasonable uses to which it may be put. It is the duty of the foreman, after being properly instructed, to see that the equipment is put to no use for which it was not intended unless actually necessary, and then only after proper investigation by an engineer.

Erection equipment should be so designed as to make all stresses as determinate as possible. Even then the many positions in which a load can and will be handled will produce more varied strains and conditions than occur in bridges or other permanently fixed structures. Be sure that all stresses and combinations of stresses are fully cared for. Then not only make the main members strong enough, but pay especial attention to details. Most failures in erection equipment are primarily due to poor details. Booms with light lacing or lacing improperly detailed are common. Poor detailing often produces very great bending stresses that are ignored.

Erection equipment should be most carefully inspected during its manufacture and test reports required for steel castings, all alloy metals and steel cables. The assembling and erection of a traveler or heavy derrick should be carefully done to insure that no stresses are introduced by improper alignment. This is extremely important. Booms and traveler hoists should be tested with gradually increasing loads before using them to full capacity. While in use they should be inspected frequently to see that no weaknesses have developed through wear or other means, and that the equipment is working as designed.

Instructions should be issued as to just how equipment on heavy work is to be used and nothing left to chance. A movement of a very short distance in the setting of a traveler, or in the radius of a heavy boom, may be perfectly safe as far as the equipment itself is concerned, but may endanger the falsework or the permanent structure.

In the erection of falsework, great care and an accurate knowledge of conditions are necessary. In case mudsills are used, examine the soil carefully and provide sufficient mudsills to support the load with ample safety.

The matter of bracing the falsework bents themselves, their connection by bracing and struts, and the fastening of the end bents to the piers or abutments so as to prevent any longitudinal movement of falsework, are all points where too much care cannot be exercised.

Twenty-two Safety Hints for Steel Erection.—Following are some cautions that if followed will prevent many of the accidents in steel erection:

(1) Select the proper man for the particular task in hand.

(2) Do not order men to work in unnecessarily dangerous places, and be on the alert to see that they do not run unnecessary risks of their own volition.

(3) Do not allow the men to work on corrugated iron roofs or steel when there is a coating of ice thereon.

(4) Walking on rods, riding loads or locomotive cranes, sliding down lines without inspecting the fastening, standing in the bight of a line, or in front of a gate block, are all unnecessary risks and should not be permitted.

(5) Do not permit men to work about crane runways without placing an effective stop between the men and the traveling crane, and see that the electric wires are properly insulated.

(6) Require the rivet boss to carefully inspect all riveting scaffolds. Improperly hung scaffolds have caused many serious accidents. Only the best material should be employed—clear spruce is the best.

(7) Pipe used as needle beams should not be spliced.

(8) All scaffold plank should have loose bolts about 6 in. from each end to prevent it from slipping off the needle beam, and if the scaffold is inclined it should have cleats nailed on the plank. All scaffold material should be tested for twice the load it is expected to carry. Even this care will not suffice unless the men are careful. This was demonstrated in a case where a gang used their scaffold as a brace for an air buckup. The scaffold—amply strong for its purpose—broke under this sudden additional load and the men fell into the river.

(9) A scaffold for use in heavy bridge construction, which gave entire satisfaction and answered all requirements, was constructed of 2½x2½x¼ angles, with a flooring of 2x10 spruce plank. The end frames were 6 ft. high, and half way between the top and bottom of the frame was a 2x2x¼ angle, to which a 2x4 hand railing was bolted. The scaffolds which were about 14 ft. in length, were swung from channels bolted directly to the members of the bridge. Two types were employed: in one the end frames were in the form of a right triangle, in the other they were in the form of an isosceles triangle, and experience proves that the latter has the more advantageous and adaptable form.

(10) Pipe makes a good needle beam but it is difficult to ascertain its condition. If used, it should have some means to prevent the rope slipping off the end. We use a shackle at each end.

(11) We have rounded the edges of scaffold plank at the ends and bound them with hoop iron. It keeps them from splitting and seems to prevent the men from using them for other purposes.

(12) Never use less than 1 in. line for swinging scaffold.

(13) Be very careful about leaving material and tools lying about on a scaffold.

(14) On high bridge work, scaffolds should be provided with a railing. This is a requirement by law in some states.

(15) Piling of material must be carefully watched, particularly with heavy work. Skids should be amply heavy and level, and the piles not topheavy. Poor piling of material is responsible for a large number of accidents.

(16) When it is necessary for men to work above other men, put up a danger sign calling attention to the fact that men are working overhead.

(17) Keeping small tools properly dressed will avoid many accidents.

(18) Wearing of goggles while chipping is a necessary precaution, but one the men dislike to follow.

(19) In the use of cable slings, inspect them frequently and keep them properly oiled, and in handling heavy loads pad the sharp corners to prevent cutting the cable.

(20) If a boom or other derrick section is bent or damaged, and then straightened in the field, do not use it for the maximum load until it has been replaced with new material.

(21) Do not put too much lashing in the hook of a gate block. It will cause the hook to open up and fail.

(22) Keep bystanders away from the work.

Wage Scale for Building Trades of Manitoba

The wage scales for construction labor in the Province of Manitoba, as recommended by the Fair Wage Board and approved by the Provincial Minister of Public Works, follow:

	Rate per hour.	Hours per week.
Common laborer	$0.45	54
Builders' laborers (being those directly engaged assisting tradesmen, not otherwise classified)	.55	54
Teamsters (employed directly from or on the buildings)	.50	60
Bricklayers	1.00	44
Stonemasons	1.00	44
Marble setters	.95	44
Mosaic and tile setters	.77½	44
Terrazo workers—		
(a) Layers	.70	44
(b) Helpers	.55	54
Stone cutters—		
(a) Carvers	.97½	44
(b) Journeymen	.85	44
(c) Planermen and lathemen	.75	44
Plasterers	.90	44
Wood, wire and metal lathers	.75	44
(a) Where metal lath only is used	.80	44
Plumbers	.80	44
Steamfitters	.80	44
Operating engineers on construction—		
(a) Engineers in charge of machines of three or more drums	1.00	50
(b) Engineers in charge of double drum machines	.90	50
(c) Engineers in charge of single drum machines	.80	50
(d) Firemen	.55	[illegible]
Sheet metal workers	.73½	44
Painters, decorators, paperhangers and glaziers	.70	44
Blacksmiths	.70	44
Electrical workers (journeymen inside wiremen)	.75	44
Structural steel and ironworkers	.90	44
Asbestos workers—		
(a) Journeymen	.80	44
(b) First-class improvers	.70	44
(c) Second-class improvers	.60	44
Asphalters—		
(a) Finishers	.60	44
(b) Men engaged preparing, mixing and heating materials	.45	54
Carpenters	.75	44

This schedule applies to the city of Winnipeg and a radius of 30 miles therefrom and dates from Sept. 1. The schedule for other portions of the Province is similar to that given above, with the following exceptions:

	Rate per hour	Hours per week.
Common laborers	$0.40	54
Builders' laborers	.50	54
Teamsters	.45	34

New Shipways at Newport News Departure from Ordinary Practice

By A. F. MATTSON, Designing Engineer.
With Walter H. Sawyer, Consulting and Hydraulic Engineer, Lewiston, Me.

There are now under construction, and will shortly be finished, at Newport News, Va., for the Newport News Shipbuilding & Dry Dock Co., two large shipways intended for building of the largest ships now afloat. In several respects these two shipways are unique and represent a decided departure from the usual practice in shipway construction. In fact, the writer believes that these ways are the only ones of their particular kind in the world.

The chief departure from the ordinary in these shipways is the location of the lower portion of the inclined plane partly below the mean water level, this portion to be pumped out and kept free of water during the entire time of construction of the ship The side walls are built watertight and the front end towards the open river is kept closed by means of large steel caisson gates, similar to the gates of a drydock. When the ship is to be launched the water is let into the ways, the caissons floated away and the ship launched in the usual manner, the difference being that a portion of the hull, the stern end, is already in the water before the actual sliding takes place. The depth of water in the shipways at mean high tide of the James River—where the shipyard is located—is 20 ft. at the seat of the caisson gates.

The general plan and cross sections of the double shipways give an idea of their size. The ways were started particularly for the construction of the largest vessels in the Government's building program.

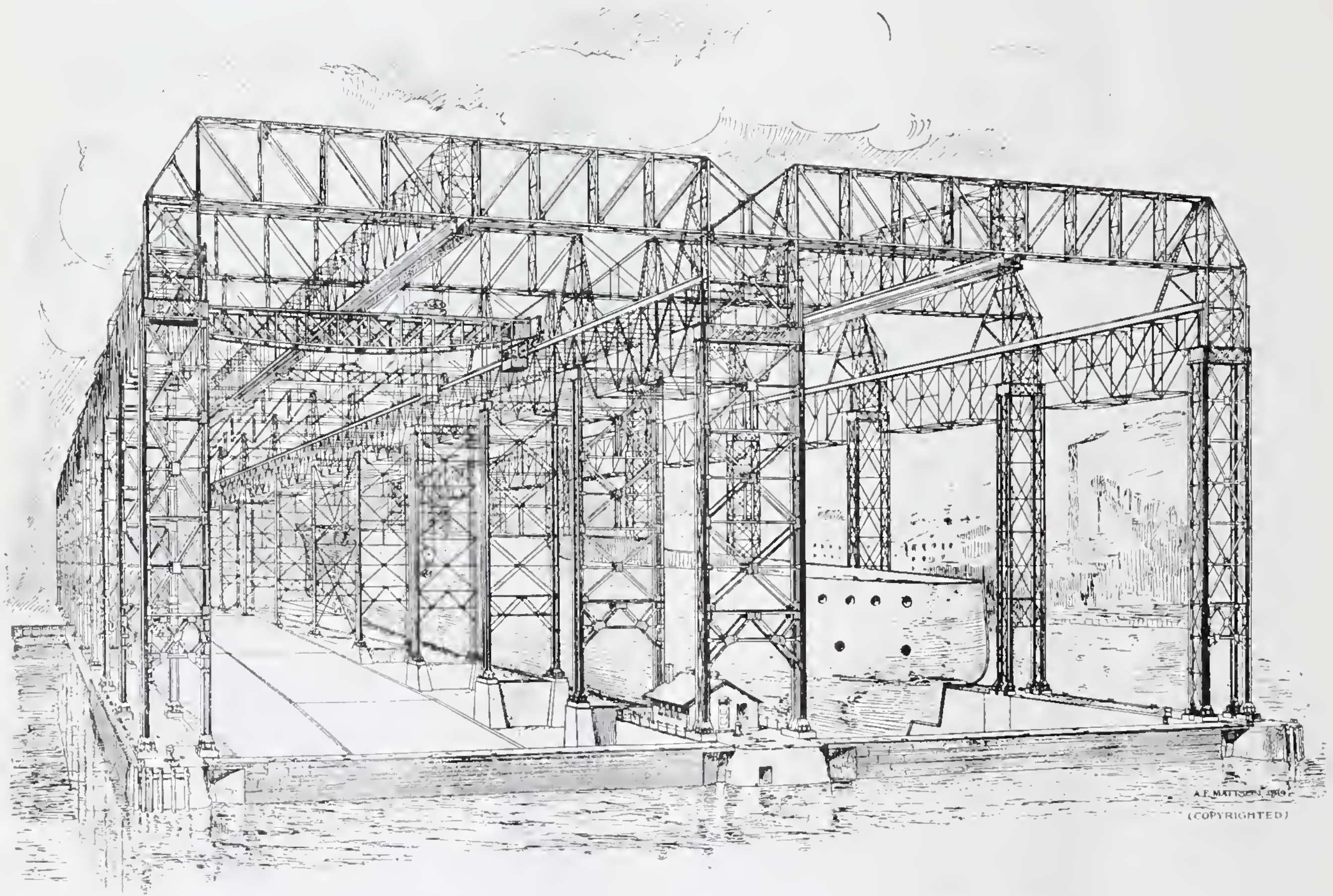
The advantages obtained by building the ways partly below the water level were several. The only portion of the shipyard available for the new ways was at the north end of the yard, and this whole area was a mud flat entirely under water at high tide. A layer of mud or river silt to a thickness of 6 to 15 ft. overlaid the firm river bottom of blue marl. It was necessary to drive piling for the entire structure, no less than 20,000 untreated pine piles being used, of a length varying from 25 to 50 ft.

On account of this low ground a shipway built above the waterline would have required a great deal of filling or else a high structure supported on closely spaced columns, well braced for sidesway. The steel structure supporting the overhead traveling cranes required for erection purpose also would have to be correspondingly taller and heavier to take care of the additional weight and wind-stresses.

The feature of the entire launchways being exposed to the eye for close inspection before the ship is launched is a most valuable matter as it does away with the necessity of relying upon the examination by a diver of the usual outboard submerged launchways.

The necessary retaining walls were built between the concrete piers forming the foundations for the structural steel columns. These walls are hollow or cellular, of reinforced concrete, built on timber piles and filled with earth to obtain stability against overturning. Walls and piers were built in sections inside of cofferdams, approximately 120 ft. long, of Lackawanna steel sheet piling, arch web section, single thickness. As each section of cofferdam was completed —the piling being driven from floating pile drivers—it was pumped out, braced, excavated to sound marl bottom, the foundation piling driven and the section concreted. The sheet piling was then pulled, to be used over again for next section of cofferdam. It was quite remarkable how watertight the sheet piling proved under as much as 25 ft. head of water and over, after fine sand or fine coal dust had been let into the interlocks between adjacent piles. The gap between the outshore ends of the side walls was closed by means of an earth filled cofferdam, consisting of two rows of steel sheet piling, 50 ft. long, driven about 30 ft. apart and tied together by heavy steel rods bearing against channel-steel walings, and filled with sand or earth deposited in the water. This earth-fill cofferdam was connected with the outshore ends of the two sidewalls, whereupon the site was pumped out and the lower portion of the ways as well as sill, gate seats, pumping plant and center piers were constructed in the unwatered area.

The plans were prepared right on the job in the field office with a small force of draftsmen. Construction began prac-



Shipways Nos. 8 and 9, Newport News Shipbuilding & Dry Dock Co., Newport News, Va.

tically at the same time as the plans and the field engineers kept pretty well in step with the designing force; as soon as a drawing was completed it was needed in the field. This procedure worked quite well on the whole. Sometimes the actual conditions of the foundations would differ from the result given by soundings and borings and the plans would be corrected accordingly.

On account of the war, competent and skilled labor was hard to get and to keep on the job. In order not to have too many difficulties, complicated details were therefore avoided as much as possible. Wall sections were made straight and simple, with straight reinforcement, easy to prepare and place in position. Uniform thickness of walls was used, with square corners and plain lines so as to avoid intricate form work. Even in spite of these precautions the work proved to be quite expensive, and it was evidenced that the efficiency did not at all improve in the proportion that wages went up, but rather the opposite took place.

The shipway floor consists of reinforced concrete caps placed on untreated pine piling. These caps, 5 ft. on centers, are generally 18 in. wide and 15 in. deep, but these dimensions vary considerably according to conditions. At the upper portion of the shipway they are low walls 12 in. thick, every 5 ft., while the heavy concentrated loading under the launchways, "the hard spots," required very close piling and instead of caps a continuous concrete slab with a thickness up to 30 in. Creosoted pine sleepers, 4x4 or 4x6 in. are fastened to or embedded in the caps, and a 3-in. plank floor spiked to these sleepers, over the entire shipway floor.

There are four trigger pits, two for each way, immediately above the high water elevation, running across the entire width of the way. Each trigger pit has a 3-in. centrifugal pump, with bottom suction, vertical shaft and electric motor drive, for drainage.

The caisson gates are being built by the shipyard of steel, hollow, similar to a ship's hull, in much the same way as caissons for dry docks, although they are probably a good deal longer than any such in existence. They will be approximately 130 ft. long, 28 ft. high, 14 ft. wide at the deck and 4 ft. wide at the bottom.

The pumping plant for operation of the ways is located centrally between the two ways at the outboard end of same and forms the abutment for one end of both caisson gates. It has one 20-in. Worthington single stage centrifugal pump, vertical shaft, for emptying the ways and one 8-in. pump to be used for removing seepage water and for tank testing of ships. Both pumps have electric motors for driving power with vertical shafts, direct connected to pumps. For flooding the ways there is a 72-in. diameter flooding duct with a 120-in. cast iron screen, in the pumping plant pier, this duct branching off into one 54-in. diameter duct for each way. The main duct is controlled by means of a 72-in. Ludlow sluice gate, with motor drive.

The steel frame for supporting the overhead traveling cranes is a very massive and imposing structure. There will be one 75-ton electric traveling crane with a clear span of 132 ft., and four 15-ton cranes of 65-ft. span, for each of the two ways. The clear width between the steel columns for each shipway is 132 ft., and the height from top of retaining walls to bottom of steel trusses is 135 ft. Each steel column or tower has four legs, each having four anchor bolts of 2¾ in. diameter, varying in length from 9 to 22 ft., according to the net uplift acting on the bolts from windpressure. There is over 7,500 tons of steel in the superstructure. The structural steel framing was designed and built by the McClintic-Marshall Co. of Pittsburgh.

The entire substructure, including concrete work, piling, excavation, cofferdam, etc., is being built under contract with James Stewart & Co., Inc., who also prepared all the plans for same, the writer being in charge of the designing for this company.

A. A. E. Opposed to Plumb Plan.—The vote on the Plumb Plan by the membership of the American Association of Engineers, to which there was referred recently a copy of the Sims Bill (which provides for the adoption of the Plumb Plan), with a request that it be read and an opinion arrived at irrespective of anything which had previously been read in other publications, indicated that the membership of the association is opposed to the Plumb Plan by a sentiment of four to one.

The Overhead Cost in Contracting*

By DAN CAREY

Imagine the contractor seated in a chair blindfolded, playing the game of Fine and Superfine which always amused us as children. The pretty girl behind his chair is Miss Business Profit. When she says "Heavy, heavy hangs over your head" if he answers "Overhead," he kissed Miss Business Profit but if he does not guess right his sentence is the bankruptcy court.

What Overhead Consists of. I have asked a great many men what they consider overhead to be. Most of them have answered that it is the cost of doing business. I think it is much more far-reaching than that I think overhead consists of three things:

First. The cost of trying to get business

Second. The cost of doing business.

Third. The cost of business you regret you are doing

Having bought a business license from the city, which permits him to start his overhead account, the contractor purchases a set of books, rents an office, puts a carpet on the floor, buys his desks, chairs, drawing board and hatrack, purchases a box of cigars which he keeps in his desk for visitors, buys a typewriter and an adding machine, hires a bookkeeper and a stenographer, buys paper, pens, ink, pencils and stationery, puts an advertisement in all the papers, sends out a lot of announcements to architects and owners at the cost of numerous stamps, begins telephoning both local and long-distance, begins buying spoons for new babies, wedding presents for prospective customers, drinks and cigars wherever they will be of benefit, Christmas presents for many, buys some technical books for his office library, subscribes to various magazines, gives a dinner to some leading architect, another to some prospective owners, joins the Builders' Exchange, joins the Chamber of Commerce, joins the Associated General Contractors of America, joins the Master Builders' Association, sometimes joins the church, but sometimes carries his religion in his wife's name. It is all overhead, with the exception of his permanent investments, and on them he has the interest on his money and the depreciation charge.

I want to deal with that question of bookkeeping and stenographer just a little, because some men appear to believe they do not have this overhead because they do not pay out money for such service. Remember this vital point, overhead exists even though you do not pay out money for it. I know a man (he is not a general contractor, by the way) who has his wife keep his books, his daughter does his stenographic work, his son is his office boy and collector. He thinks he is paying them by allowing them to bear his name, I presume, because he does not pay them salaries. Recently I had a talk with him about the miserably cheap bids he is submitting, and he gave me with evidence of glee the facts I have given you as to why his overhead is less than that of his competitors. I contend that even if a man is his own bookkeeper, writes his own letters and collects his own bills he is entitled to pay himself whatever amount he will have to pay to have these services performed when he breaks down from overwork, gets sick or dies.

The same thing applies to his own drawing account. I know a plumber who allows himself $15 per week as a drawing account and he admits he could not hire a manager for his business for less than $75 a week. This plumber is not allowing a fair charge for this feature of his overhead. I have heard a great deal of discussion about a proper drawing account in business. Some men contend a man is entitled to draw what he thinks he is worth to his business; that is dangerous. Others say the proprietor should draw what someone else would pay him; that's problematical. The real test is the cost of employing someone to conduct the business for him That figure can be ascertained almost exactly.

Now, should a man pay himself a salary for operating his own business? He need not take the actual money if he does not want to, and can leave it in his bank account, but unless he figures the amount in his overhead he is doing his business an injustice. If he is conducting a real business he is so operating it that it will continue uninterrupted when he is taken ill, or gets an automobile accident, or falls off a scaffolding or dies. And unless he has a business which will continue as a business for his wife and family after he is dead, or while he is disabled he is operating a day labor establishment and not a place of business.

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*From a paper presented before the Master Builders' Association of St. Louis.

Some Other Features of Overhead.—I have mentioned the business license. There are also the taxes, municipal, state, county and national, and all of you know the item is considerable. You have items of insurance which cannot be charged to the job. There are pictures of the work you do, and I think that some of you would find this a very profitable feature of overhead in securing business from future customers. Don't forget legal expenses, which includes the advice from your attorneys, special contracts he has to draw for you and the charges he makes for settling suits against you and your suits against others. Then comes the rental you pay on equipment which you do not feel like buying. Figure out the interest on your entire investment and add that into your overhead, because if you did not have your money invested in equipment you would have it drawing money in a savings bank, and anyway the bank charged you interest on the money when you borrowed it.

Then there is your lost time. That is quite an amount of you will look into it properly. Your men finish work on a job at one end of town. You transfer them to an entirely different section. Three hours is lost. That's overhead. Or you find it necessary to keep your men on the payroll a couple of days because you want to hold your force for a new job. That's overhead. Or it is necessary to send some men out to adjust some doors or windows that damp weather swelled up after you finished the job and received your pay. That's overhead. I know a contractor who repaired a crack in a brick wall on account of poor foundation work, and he repaired it, even though he had not done the foundation work, because he was getting credit for the building and the discredit for the crack. That was overhead.

Don't forget our beloved citizen who finds that your work was not what he expected it would be, or who finds flaws with your work and who insists that from $50 to $500 be knocked off the cost of the building. Every time he swindles you out of a dollar he has added a dollar to your overhead. Then there is the widow of your life-long friend who builds a home with his insurance money, and who gives you the contract. After you have made your estimate she has two bathrooms instead of none, two sleeping porches instead of one, substitutes hardwood floors for the original pine, changes her hardware, builds a pergola, paves it with tile, and then calls your attention to your letter in which you told her what you would build her home for and refuses to pay more. You can't sue the widow of your dear friend. The dear lady has simply added to your overhead.

Please remember your trucks and your automobiles and include the cost of them in your business. I mean even your private automobile which you use all week in your business and for joy-riding on Sunday. Last Friday I had a talk with a roofer who told me he was doing business at a cost of eight per cent. When I laughed at him he agreed to discuss the matter. Of course, I at once ascertained that his overhead was much more than he estimated, but among other things I found that the automobile which he uses to secure business was purchased personally by one of the stockholders in the business, and that the stockholder paid the entire cost of operating and repairing the auto. It was rather a curious arrangement, I thought, but I accepted the statement of course. I told him if he was using an automobile in his business the cost was there, no matter who paid. He admitted that, but said it was a contribution and therefore he did not carry it in overhead. Finally, I put it to him this way, and he saw the point: I said, "Now, listen to me a minute. This man is contributing an automobile to your business, but you are not including it in overhead, is that correct?" He said it was. "Then," I said, "if you are not including it in overhead, you are deducting it from the price of your roofs, isn't that true?" He admitted it was. "Then," I concluded, "don't you see that this man isn't contributing an automobile to your business at all, but is simply, as a result of your business methods, contributing to the cost of laying roofs for owners, something which he doesn't intend to do at all, and a thing which the owners not only do not know about, but would not appreciate if they did."

The Federal Trade Commission about two years ago issued a pamphlet on this subject, in which the statement was made that failure to understand what overhead consisted of and failure to include it in charges to customers was the chief cause for the business death rate in the United States. Why fool yourself? Construct buildings at a profit of one-quarter of one per cent if you want to, but don't try to convince yourself when you do that you are making 10 per cent. A man ought to be honest with God and his fellow man for the sake of his soul. A man ought to be honest with his wife because it is right to be honest with her. A man ought to be honest with himself because he is a man, and because he cannot be a man unless he is honest with himself. Therefore, be honest with yourself. Don't cheat yourself out of your overhead. Play the game square with yourself at least.

How to Figure Overhead and Proper Selling Price of a Job.—I am going to take it for granted that you do not know how to figure the overhead into your business and I am going to take it for granted that you do not know what the selling price of a job ought to be. In order to discuss the last point it is necessary to lead through the first. If you do a business of $100,000 a year, and after keeping books for 12 months on what I have enumerated above, you find that your overhead is $10,000, then it is perfectly evident that you are doing business at a cost of 10 per cent. In other words, by dividing the gross amount of your overhead charges for any given period you ascertain the per cent you are paying to operate your business.

We now arrive at the final stage: What is the proper selling price of a job. The selling price, by which I mean your estimate, what you will construct the building for, is made up of your raw cost, plus your overhead, plus your profit. If a contractor says he has done $100,000 worth of business, and has made 10 per cent on it, the natural inference is that he has made $10,000 and is ready to put it in the bank or invest it. When you tell your customers that you make 10 per cent on their jobs they believe you, but I don't, and neither does your banker. We know better. You are simply getting the reputation of earning 10 per cent without getting the money.

You all know and admit that there are 3 ft. in a yard and 12 in. in a foot. You can adopt some private system of measurement if you want to, something that will be known only to yourself, but whenever you sell a man a 50-ft. lot he is going to expect you to deliver 12 in. in every foot of it. That is standard. It is fixed. So also it is with every other measure in the world. Now, the same parties who declared that there should be 12 in. in a foot also announced that in every completed thing in the world there should be 100 per cent of something. It makes no difference whether it is a common brick, a picture, a continent, an arithmetical figure or a building that has been constructed, it consists of 100 per cent of something, and by the same token the price you receive for constructing that building consists of 100 per cent. The price the owner pays should consist of raw cost, overhead and profit. If you leave out your profit the 100 per cent consists of raw cost and you are building without a profit. If you leave off both your profit and your overhead, or if you do not put in enough to take care of your overhead, you are erecting the building at a loss.

Let's take an example. Say the raw cost (by which I mean labor and material) is $85,000. Say your cost of doing business is 5 per cent. Say you want to make 10 per cent on the job. Your estimate to the architect or owner should be $100,000. We arrive at this figure by adding your 10 per cent, and your 5 per cent together, making 15 per cent. This 15 per cent is subtracted from 100 per cent. Why? Because 100 per cent is what the estimate will contain. Fifteen from 100 is 85. Next, divide your raw cost by 85. The result obtained is $100,000, which is your proper figure. You have then allowed 5 per cent for overhead, which is $5,000, and 10 per cent for profit, which is $10,000, and the job figures up this way:

Raw cost	$ 85,000
Overhead	5,000
Profit	10,000
Total	$100,000

Now, instead of figuring the way I have done, let's figure the way I know some contractors do figure. Say the raw cost is $85,000, and say that overhead is 5 per cent. The general contractor wants to make a 10 per cent profit. He adds 10 per cent of $85,000, which is $8,500 to $85,000 and arrives at $93,500. He shoots this in as his estimate and gets the job. His overhead is 5 per cent, which is $4,675, and when we subtract his overhead from $93,500, which was all he got, we arrive at $88,825, which is only $3,825 more than his raw cost; yet he believes he is making 10 per cent and gets the credit or discredit of making 10 per cent, when as a matter of fact, he makes only a fraction more than 4 per cent. He fools himself and deceives his customers to his own detriment.

The only thing I shall say in conclusion is that the prominent man in any community, the respected man, the man whose advice is sought and whose judgment is looked up to is the successful man, the man who has made money out of his business, who has figured his overhead and his profit into every job that he has done, who has thought so much of his own ability that he has demanded pay for his services in full, who has laughed in the faces of the men who wanted him to work for nothing, and who at the end of his career has laid aside sufficient money to support him in his old age. The man with last year's hat, the shiny coat, and the frayed breeches may have the nobler heart and the better character, but his business judgment is not respected.

Under Water Method of Driving Piles

Pile driving through 70 ft. of water was one of the interesting features in the construction of the new Bear River bridge in Canada. This bridge is located on the Yarmouth N. S. subdivision of the Dominion Atlantic Ry. and was completed in June, 1914. The underwater method of driving piles was employed for two of the piers. At these points borings showed a considerable depth of mud, so it was decided to excavate about 15 ft. and drive piles. After the excavation was complete there was a depth of about 35 ft. of water at low tide. The method followed in putting down the piles was described as follows by Mr. A. T. MacDonald in a paper presented at the recent convention of the Engineering Institute of Canada.

The guide pile and hammer were handled by a stiff leg derrick operated by a 25-HP. 3-drum hoist. The guide constructed of four 3½-in. steel angles latticed together, was 22-in. square inside measurements, and all rivets were sunk on the inside. It was made in 15-ft. sections capable of being bolted together to give the required length. Lugs riveted to the top section rested on crossed timbers on the cofferdam and the guide hung there from, just clear of the bottom of the excavation and over the spot where the pile was to be driven. The pile was then inserted in the guide and allowed to drop to the bottom. With heavy piles as much as 10 ft. penetration was obtained in some cases right at the start. The hammer weighing about 5,000 lb., was built to give a clearance of about ¼ in. all around inside the guide and terminated in a truncated pyramid. The hammer was lowered into the guide after the pile, and driving commenced, a fall of from 12 to 15 ft. being given. The fall was thus limited as it was found that the pile heads broomed badly. The piles used were exceptionally good, but many of them failed to stand up under this treatment. The maximum penetration obtained was 46 ft. while test piles, driven from the same location from a scow with a 2,400-lb. hammer and a dolly gave a penetration of 65 ft. However, the big advantage of being able to drive under water was that the work could go on at all stages of the tide and this meant at high water the driving was being done through 70 ft. of water.

Loss from Rusting of Steel.—It is now quite universally admitted that the rusting of iron and steel is one of the serious industrial problems, states the Valve World. If we assume an average life of steel to be 33 years, the depreciation charge of 3 per cent represents, according to the United States Bureau of Mines, a yearly loss of 1,000,000 tons of product in this country for the crude or semi-finished material alone, exclusive of correlated manufacturing costs. The inevitable rusting of steel may be justly claimed to be the mainstay of the zinc industry, as 60 per cent of the metallic zinc used in the states is for galvanizing iron and steel articles, representing an annual outlay of $20,000,000 in an endeavor to protect metals from decay. Enormous amounts of paint are used in a like endeavor. About 5,000,000 tons of coal are needed in the production of steel to replace the annual waste, and 1,000,000 more for replacing the zinc that is annually lost.

Cost Plus Contract With Minimum Fee Guarantee

A cost plus form of contract containing a carefully worked out plan for adjustment of the contractor's fee has been prepared by Gannett, Seelye & Fleming, Engineers, Harrisburg Pa. The essential features of the plan are the submission of an estimated cost, based on the unit quantities furnished, together with the percentage fee asked by each contractor who bids on the work; preparation of a corrected estimated cost at the completion of the job; a deduction from the contractor's fee in case the actual cost exceeds the corrected estimated cost, or the payment of a bonus, if the former cost is less than the latter. However, the contractor is guaranteed a minimum fee in any case.

This contract form was developed for use on the construction of a reservoir and dam, and is the result of considerable experience with cost-plus work on the part of the engineers. As the job is not yet completed, it is too early to state just how satisfactory this contract will prove to be from the standpoints of the engineer, owner and contractor, but it gives promise of working out well.

The following paragraphs, which are taken from the contract, furnish in detail the agreement as to the contractor's fee:

> In case the amount of work actually done in any of the classes for which unit prices are given above is greater or less than that given in the list of quantities, a corrected estimated cost shall be computed using the contractor's estimated unit prices and actual quantities, to which shall be added the actual cost of all extra work authorized by the engineer and not included above. This sum shall constitute the corrected estimated cost upon which the fee of the contractor shall be based.
>
> As full compensation for the service of the contractor including profit and all general overhead expense, except as herein specified, the water company shall pay to the contractor in addition to the actual cost of the work as defined above, a sum of money equal to —— per cent of the corrected estimated cost.
>
> It is specifically provided and agreed that in case the actual cost of the work exceeds the corrected estimated cost, the contractor shall be penalized by deductions from his final payment, as follows
>
> A penalty of 25 per cent of the excess cost up to an excess of $10,000, and a penalty of 50 per cent of all excess above $10,000; but in no case shall the contractor receive a net fee of less than 3 per cent of the corrected estimated cost, after penalties for excess cost and for time in excess of time agreed upon for completing the work, only, have been deducted from his total fee
>
> It is also specifically provided and agreed that in case the actual cost is less than the corrected estimated cost, the contractor shall receive a bonus in addition to his final payments as follows:
>
> A bonus of 25 per cent of the saving up to a saving of $10,000, and a bonus of 50 per cent of all savings above $10,000.

Commenting on the contract, a weekly news letter of the Associated General Contractors of America says:

"In view of the control over the execution of the work that is given the engineer in such a contract as this, and the possibility, in consequence, of his arbitrarily delaying the work or forcing a more costly procedure, should this type of contract be widely adopted, it would seem that a minimum fee of three per cent is too low for general use. The proper value for the guaranteed fee, as well as the basis for figuring the penalty or bonus would necessarily depend upon conditions on the project under consideration."

The attitude of Gannett, Seelye & Fleming toward cost-plus work and toward this particular type of contract is explained in the following quotation from their letter:

> Our reason for developing this form of contract and using it under these conditions was largely the result of having successfully used similar contracts, although not so carefully worked out, on other work.
>
> We have felt that the employment of a contractor should be more or less on a professional basis, and the client should be free to select contractors for other reasons than cost. We are not perfectly sure as yet that contractors use as much energy in keeping down their costs under this form of contract as under the ordinary unit price contract, and are a little afraid that contractors as well as their clients must accustom themselves to this kind of contract if beneficial results are to be assured
>
> In the present state of affairs, if the contractors have several unit price contracts, and also one or two cost plus contracts, it would be my guess that the former would receive most attention. Were all work on the cost-plus basis this difficulty would probably be eliminated. We can tell you better what we think of this form of contract when the dam which we are now working on is finished and the cost and the success of the undertaking are determined.

Load Concentrations on Steel Floor-Joists of Wood Floor Highway Bridges

While wood planking floors on I-beam and channel joists are no longer employed on main highway bridges if their use can be avoided, yet on secondary roads and on bridges now in service and especially on those of such design that the trusses will not carry the additional load of a concrete floor, wood plank floors still have their place. It is true economy to keep the latter structures in service as long as the trusses remain in good condition, and as long as the floors can be maintained to carry the tractor and motor truck traffic. Under the direction of Mr. T. R. Agg, and Mr. C. S. Nichols of the Iowa State College of Agriculture investigations have been made to determine the manner in which heavy wheel loads, such as those of traction engines, are distributed to the various I-beams and channels in a highway bridge floor system consisting of I-beams and channel joists and wood planking. The results of this investigation are given in Bulletin 53, issued recently by the Iowa State College of Agriculture and Mechanic Arts. The matter following is taken from the bulletin:

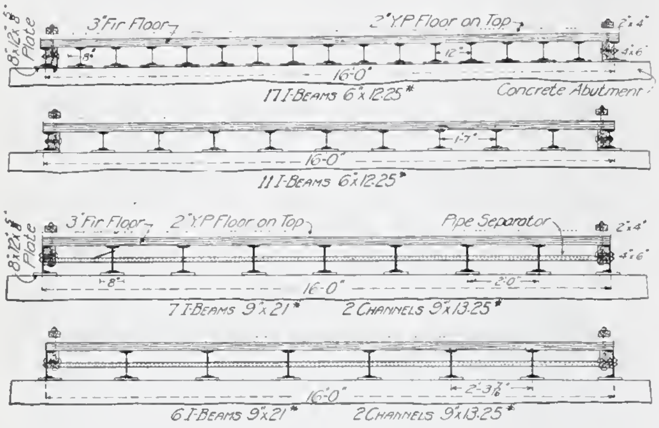

Fig. 1—Types of Floor Systems Studied.

Scope of Investigation. The investigation was confined to the following:

1. The determination of the percentage of a wheel load carried by each I-beam and channel joist of a highway bridge carrying a wood floor, for various positions of a certain pair of tractor wheels.

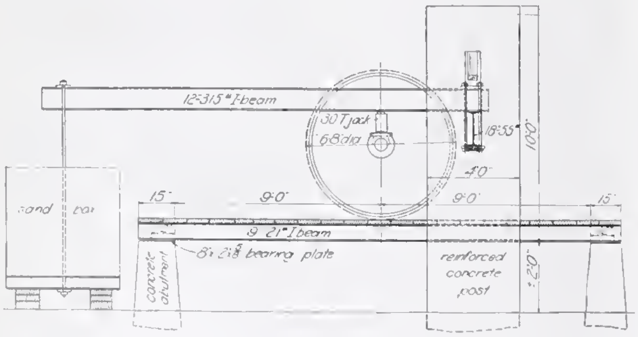

Fig. 2—Side View of Loading Apparatus in Place.

2. The determination of the effect of using two layers of floor planks, the upper one being laid (a) lengthwise of the floor, (b) on a diagonal.

3. The determination of the effect upon distribution of load of loosening the planks from the nailing pieces.

4. The determination of the effect of the wheel lugs upon the distribution of the load.

Method of Conducting the Investigation.—Two low concrete abutments were built of such dimensions that they would accommodate a floor system identical with that employed by the Iowa Highway Commission for an 18-ft. span with 16-ft. roadway. Metal bearing plates were used on the abutments so as to give a clearly defined span length of I-beam. Modifications of the standard design were also employed to secure data relative to load distribution on light I-beams. Figure 1 shows the various types of floor systems studied.

The load was applied to the axle of a pair of tractor wheels by means of hydraulic jacks and the loads given in the various diagrams include the weight of wheel and half the weight of the axle. The general arrangement of the load apparatus is shown in Figs. 2 and 3. Repeated trials with this apparatus showed that loads could be repeated with exactness, but it is possible for the loads given in the diagrams to be in error by 5.0 per cent and the percentages of concentrations may be in error by 5.0 per cent, although the average error is probably less than 2.0 per cent. The wheels were placed in a symmetrical position on the floor at the mid-span, and one, two and three feet off the center line of the bridge at mid-span, a total of four positions for each floor system studied. These various positions are indicated by the letters A, B, C, and D in the diagrams.

Diagrams for the floor consisting of 6 I-beams, 9 in. by 21 in. and 2 channels 9 in. by 13.25 in. only are shown. Similar results were obtained and are illustrated for the other floors tested.

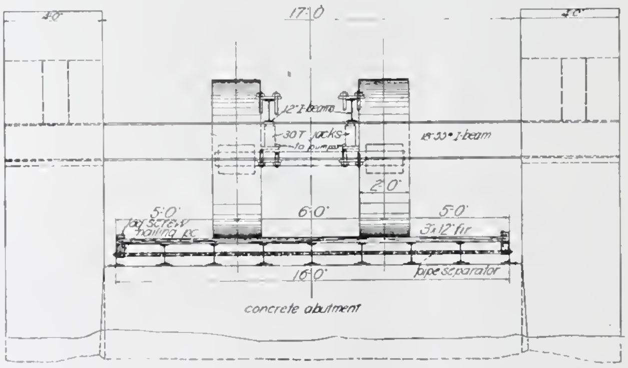

Fig. 3—End View of Loading Apparatus in Place.

The lower flanges of the I-beams and channels were drilled for a 15-in. Berry strain gauge, the gauge lengths being symmetrically laid off from the middle of the span and being continuous. Before the I-beams were placed in the bridge, they were loaded by means of a standard beam testing machine and the strain corresponding to various concentrated loads measured with the strain.

In the floor tests the wheels were raised from the floor and zero readings were taken on all of the gauge lengths on the I-beams and channels. The wheels were then placed in the desired position and the pressure applied by means of the jacks. This load was maintained while the strain was read on all gauge lengths. A second load considerably heavier than would ordinarily result from any vehicle now using highway bridges was then applied and the gauge readings again recorded. Each final value of strain for a given load is an average of at least three separate determinations in which the individual determinations checked within .0002 in.

Calculations.—It was expected to plat the moment diagram

TABLE 1—CALCULATED CONCENTRATION OF LOADS ON FLOOR JOISTS.

Joist.	Average reading of strain gauge. No. load.	Load 29,400.	Difference.	Calculated load on joist lbs.	Percentage of one wheel load
Channel A	—26	—25	1	75	.50
I-beam B	10	30	20	2,850	19.40
I-beam C	—36	14	50	7,100	50.34
I-beam D	—25	4	29	4,000	27.20
I-beam E	—12	22	34	4,600	31.30
I-beam F	—79	—29	50	6,975	47.44
I-beam G	—11	10	21	3,100	21 10
Channel H	—24	19	5	400	2.72
Total calculated load				29,400	200.00

Actual load, 29,800 lb. Ratio calculated load to actual load, 0.986.

for each I-beam and for each load, calculated from the elongation of outer fiber which had been measured by the strain gauge, and from these diagrams compute the load. Upon platting the moment diagrams, it was found that the load acted very nearly as a concentrated load at the middle of the I-beam, and that to so consider it gave results sufficiently near correct for the purpose of the investigation. Table I shows the calculation of concentration of load on each I-beam, and it will be noted that the sum of the calculated loads on all of the floor joists is 29,400 lb., while the actual load is 29,800 lb., the error being 1.4 per cent. As a rule the error was slightly greater than this, although in no case was it greater than 5.0 per cent.

The diagrams in Figs. 4 and 5 are drawn to show the concentration of load on each joist in the floor system in percentage of one wheel load. They illustrate the variation in concentration for the several positions of the wheels. The lines are drawn to connect points of calculated concentration and do not indicated the rate of change between points.

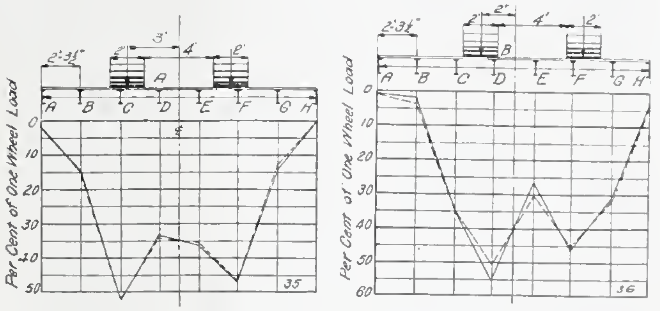

Fig. 4—Floor System, Consisting of Six 9-in. 21-lb. I Beams and Two 9-in. 13¼-lb. Channels.

Floor of commercial 3 by 12-in. fir laid transversely with ends fastened to nailing pieces on the channels. Solid line connects points showing concentration for load of 14,900 lb. at each wheel and dotted line connects points showing concentration for load of 18,900 lb. at each wheel. Positions A and B in this figure.

It is not shown by the experimental data what effect diameter and width of wheel will have on the concentration, but it seems probable from a study of the diagrams of concentration and from the observations of the progress of the experimental work that the results given herein will closely approximate those with any other diameter and width of wheel likely to be employed for motor trucks or traction engines weighing in excess of four tons.

Conclusions.—The conclusions as given in the bulletin are as follows:

A concentration on a single floor joist, equal to 55.0 per cent of one wheel load is possible where a single thickness of wood floor is laid on the steel floor joists.

The concentration on the joists immediately under the wheels is generally increased slightly if the ends of the plank are loosened, but the additional concentration is small.

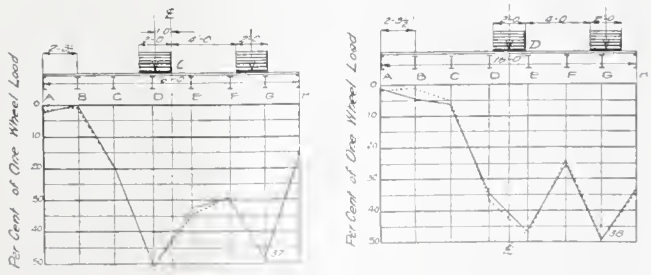

Fig. 5—See Note for Fig. 4, Positions C and D, in This Figure.

The concentration on the joints immediately under the wheels is slightly reduced by a second layer of floor planks laid lengthwise of the bridge floor.

The concentration on the outer I-beam or channel increases rapidly as the load approaches the side of the bridge. The outer joist should have a section modulus as great as that as of any other joist in the floor system.

The concentration on light I-beams used for joists and placed at the intervals as shown in Fig. 1 is much less than on the heavier I-beam joists with wider spacing, so they may be safely employed if enough are used to insure wheel bearing on two joists.

Advantages of the Cost Plus Form of Contract*

It was suggested to me that I address my remarks to the general subject of the method of contract under which construction operations can be most effectually and equitably carried out. It is with a certain amount of diffidence that I undertake such a discourse, for the subject is so vast and there are so many matters that bear upon methods and forms of contracts for construction work, that in an address of this nature a speaker can at best speak only in very general terms.

I can say truthfully that I am quite familiar with the working of one particular form of contract; that is, the form of contract under which the construction work for the army has been carried on during the period of the war and under the provisions of which construction work was undertaken and is being brought to a close, aggregating in cost in the neighborhood of $1,000,000,000.

The contract which finally was adopted for the building of the camps and cantonments is known as the emergency form of contract. In popular language, it is called a cost-plus contract, but strictly speaking it is not exactly that, but a modified form of the cost-plus idea. The natural advantages of this form of contract are well recognized, and this method of contract for the performance of construction work has been for a number of years steadily growing in favor. It is equally flexible for large and small projects, and adjusts itself automatically to variations in plan and to additions to or curtailments from the original estimates. It is equally valuable in stable or unstable market conditions. Under it work can be started as soon as the organization is on the ground, and the planning of the work can go hand in hand with the actual construction. The disadvantages are that it requires vigilance on the part of the owner, a painstaking check upon all construction costs, and that it encourages extravagance on the part of the contractor and offers temptations for increased cost, accompanied by increased compensation to him.

Modified Form in Cost Plus Contract Used by Government.—In the contract adopted, the cost-plus principle governed, but there are a number of variations from the usual cost-plus contract. There may be cost plus a fixed percentage, cost plus a flat amount; cost plus a sliding scale of percentages, the percentage decreasing as the cost increases; or cost plus such a sliding scale with an upset price fixed, beyond which the contractor can receive no compensation, no matter what the cost of the job. The last named of these forms was the one adopted by the construction division with the advice of the committee on emergency construction. In the original contract for the cantonments, if the cost of the work was under $100,000 the contractor's fee was 10 per cent; if over $100,000 and under $125,000, 9 per cent; if over $125,000 and under $250,000, 8 per cent; if over $250,000 and under $266,666, $20,000; and so on down, until it was provided that if the cost of the work was over $3,500,000 the contractor should get a fee of 6 per cent. A special provision was inserted into the contract that the total fee to the contractor should, in no event, exceed the sum of $250,000. These figures were inserted, as I say, in the original contracts for the construction of the national army cantonments where the cost was estimated to run about $6,000,000 each. Based upon such figures, the contractors' fees would have been about 4 per cent of the total cost of each project. Actually, due to alterations, enlargements and changes in plans, the cost ran in every case considerably in excess of what had been anticipated. The $250,000 fee, however, remained. It will be observed that, based upon a foundation of percentages, the contractor passed, comparatively early in the building program, the point where all of his fee had accrued. In other words, after this point had been passed, his fee was not increased by a single penny. Consequently, it was to his advantage, both for his reputation and to cut down his own overhead, to finish up the job as speedily and economically as possible.

This principle has been followed with all the emergency construction work done by the construction division. The upset fee, of course, has varied in size as the jobs varied in size, but in all jobs of magnitude it has remained constant at $250,000 except in one instance where, by special arrangements, it was made larger on a job costing between $25,000,000 and $30,000,000. If, on the other hand, it was anticipated that the project would not cost more than $1,000,000, the fixed sum, which could in no case be exceeded, representing the maximum fee which the contractor could get, was made correspondingly smaller. The effort was constantly to check any possible tendency toward extravagance or prolonging the job, in order that the fee might be correspondingly enhanced. It is only fair to the contractors to state that this tendency, the possibility of which is very generally recognized and the existence of which was quite widely asserted by persons not familiar with the War Department construction, was never noticeable, and I believe it never was consciously a policy which any contractor on our jobs tried to follow. None the less, the insertion of the upset fee, judiciously calculated to correspond with the probable cost of the work, was a safeguard the moral effect of which it is hard to overestimate. If any such tendency had existed, it would have effectually operated to check it by rendering such a course of action quite as undesirable from the contractor's standpoint as from that of the Government. It was an answer to charges of ill-advised and gratuitous critics of War Department construction work to which they could never find a satisfactory rejoinder.

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*Abstract of an address by Brig.-Gen. R. C. Marshall, Jr., Chief of Construction Division, U. S. Army, Washington, D. C., presented before the Boston Society of Civil Engineers, and the discussion

The percentages have been changed from time to time, in accordance with the lessons of experience, but the fundamental principle governing the form of contract has been retained all through the construction work for the army during the war. It has been proved to my satisfaction, and to the satisfaction of those who have followed the work, that this form of contract has worked as well, probably, as any scheme of human devising ever does. The tendency to unwarranted extravagance on the part of the contractor is effectually checked, if not prevented, and, coupled with a jealous and effective system of auditing, also provided for in the contract, the rights of both parties are amply protected.

Without the form of contract which was adopted, it is a certainty that the camps and cantonments could not have been built. It worked so well in these projects that it has been in use, with non-essential modifications, ever since and in all kinds of construction work. It has given universal satisfaction to the division and to the contractors.

Possibilities of Cost Plus Contract for Peace Time Construction.—In all the vast program of building, both that of the simplest nature and that which presented the most difficult technical engineering problems, this form of contract has worked smoothly and well. Whether or not it can be employed to equal advantage during ordinary times and under normal conditions, may be open to question, but I can think of no valid reason why it should not be, given the safeguard of proper checking of costs on the part of the owner or his representative. It relieves the contractors of most of the hazards of that most perilous of undertakings—figuring on a big job in times of unstable market conditions. It relieves the owner of the payment of an extra fee representing the amount which the contractor must add to his bid as a safeguard against a possible rise in the market. It is at least worthy of careful consideration, and is, no doubt, capable of further refinement and perfection.

Possibly this contract would not be the best for ordinary small building operations such as those conducted by individuals building their homes or small commercial buildings. It might be difficult for the owner to keep in action a system of auditing and checking which is essential to proper operation under this form of contract. I am far from desiring to create the impression that contractors are naturally dishonest and have to be watched. On the contrary, I am very strongly of the opinion that no body of men in the country are more jealous of their reputation or realize any more vividly the value of an established name for honesty and fair dealing, but when every expenditure made by a contractor is paid for by the owner and these expenditures themselves are made the basis of the contractor's remuneration, it is only just to him, as well as to the owner, to have a careful and accurate audit of all such expenditures. Such an audit is probably impracticable in small building operations.

In such operations, given market conditions of normal stability, the ordinary lump-sum contract should work well. Usually there is no difficulty in knowing just about what is desired, and as time is ordinarily not of the essence of the transaction, there can be close and careful estimates made and bids submitted which will be fair alike to both contracting parties.

It is not with this class of building operations that I and this audience are principally concerned. I have in my mind jobs which cost from $500,000 upward. Here we are met with different circumstances, and these call for different methods of operation. I believe that it is in such a field that a contract approximating the one which the construction division has used during the war will have most value. It is in figuring contracts of this size that the element of chance enters most largely. Contracting on a large scale is a gamble. The contractor wants the job upon which he is figuring, and he desires to do it more cheaply than his competitor, but at the same time he is, if he desires to remain solvent, exceedingly careful not to be caught by changes in the market or by labor disturbances. Some margin of safety he must have, and for this margin of safety the owner pays. There is inevitably a sum larger or smaller as the case may be, but always, in big operations, very considerable, over and above the amount of profit with which the contractor would be satisfied, which the owner has to pay—that is, the margin of safety. When a contractor figures a lump-sum contract, he takes a chance. All he desires is a fair and just remuneration for his work, his experience and the use of his organization, over and above the expenses to which he is actually put, but he is taking chances not only on wind and weather and the ordinary hazards of building, but he is also gambling on the market, on its stability, and in order to play safe he has to put his figure higher than the sum which he would be willing to accept if he was assured of safety. Even then, sometimes he gets caught. Cast about in your minds and try to remember how many contracting firms have been forced to the wall or have been seriously crippled because of an unfortunate bid upon some large building, project, apparently safe, perhaps, when it was made, but which resulted disastrously for the contractor. I contend that the lump-sum contract in large operations works a double hardship: on the owner, because he pays more than he should have to in order to insure a measurable degree of safety to the contractor; and a hardship to the contractor because in spite of sound business judgment, good estimating and a knowledge of conditions, he sometimes inevitably is financially embarrassed or rendered totally insolvent through changes in the market or fortuitous circumstances which he could not foresee.

I believe that the cost-plus contract, with a definite fixed sum, and with suitable auditing and checking, is the way out for both parties, and I commend it to the great organizations of this country concerned in the building of its gigantic construction operations for consideration.

Advantages of Placing Construction Work of Great Size Under One Central Authority.—I wish to allude to the advantages which always come from the consolidation of construction work of great size under one central authority, composed of an organization of experts in that particular line. The construction division was exclusively composed of men drawn from civilian life eminent in their professions—architects, engineers and builders. It was charged with construction work and construction work alone. It was not burdened with side issues; it had nothing to do with anything but providing the necessary building for the War Department. Soon after it had demonstrated its efficiency, in October, 1917, the Secretary of War placed all of the War Department construction work under its jurisdiction. Formerly the various bureaus—the Signal Corps, the Ordnance, and other divisions of the War Department—each, in addition to its other specialized duties, had been undertaking to do the building necessary for the accomplishment of its particular task. It is no reflection upon these bureaus to say that the results were not all that they might have been. Building was not their job; it was a side issue. When building was all consolidated where it should be, under a department devoted exclusively to that task, an improvement in results was almost immediately noticeable.

The same principle might, it seems to me, be applied to our Government on an even vaster scale. At present the Government construction work is being carried on by the various executive departments, which each handles independently of the building incident to its particular functions. The Treasury Department, the Navy Department, the War Department, the Department of Agriculture, the Department of Labor, the Department of the Interior and the United States Shipping Board, are each charged with the construction work of its own governmental functions. In other words, these departments are all, to a certain extent, bidding against each other; each is undertaking, as a sort of side issue as it were, a task which is not directly connected with its ultimate object or purpose. It would be well, in my opinion, to consider very seriously the formation of a Department of Public Works under which would be consolidated all of the building for the Government. A moment's reflection will convince any one of what a tremendous executive branch this would constitute—a branch expending probably 20 per cent of the annual appropriations made by Congress. That such a branch, properly constituted and combining in itself the best talent of the various engineering bureaus and architects from civil life, which have been brought in to assist in the emergency, could effectuate tremendous savings and could accomplish the Government building to far greater advantage than it is at present being conducted, is indisputable.

A closer rapport between the Government and the great contracting organizations would be possible; and also—a thing of tremendous importance—closer and more intimate relationship between the Government and the great engineering societies of the country would result. These organizations and associates are indispensable, of course, in time of peace as well as in time of war; but when a national crisis is at hand their aid must be enlisted at once, and in times of crisis, speed is the essence of accomplishment. During the past few months, so filled with events, the response of these organizations and societies has been so generous as to be inspiring, but from the constitution of the governmental agencies with which they had to deal, the greatest measure of good has not always been possible. With the establishment of such a department of public works, it would be the one agency with which they would all be in more or less constant touch and by which they could be recruited at any time of need. My own idea is that such a department should be under a cabinet officer, and that, properly administered, it would be second in importance to scarcely any of the executive branches of the Government.

Discussion by Frank M. Gunby.*—In connection with the emergency construction contract, I want to say that I think a tribute is due to the farsightedness of the men who evolved or put together that contract. I say "put together" advisedly, because it is a combination of forms of contracts used by engineers and contractors all over the country, with just enough modifications of the good points selected from various contracts to fit it into governmental procedure.

As we were spending Government money, we had to spend it the Government's way. Sometimes that slowed up the game, as compared to what could be done without such requirements, but I think it is a further tribute to the judgment of those men to say that, due to the business scheme that they laid down and the type of contract they worked out, supplemented by the administration of that contract by the construction division, the construction division was utterly uninterested as to whether congress passed that validation act or not There wasn't a single informal or illegal contract in the whole war construction program as administered by the construction division.

Some of us in our previous experience have viewed with tolerance or kindliness, and even with enthusiasm, the use of the lump-sum contract for construction work. I was in that category and always had the feeling that where that form of contract fitted, it was probably the best to use. The experiences of this war have led me to believe that there are certain limitations that we should understand in applying that contract, and I will give you what my opinion of them is.

I say this from the standpoint of having helped administer about 550 of the other kind (cost plus a limited fee), so I feel a little bit qualified to say something about both.

I would be a bit inclined to establish as proper conditions for a lump-sum contract, three things:

First, an ability to clearly define what you are contracting for. Meaning by that, definite plans and specifications, both as to the limits of what you are contracting for and the type of what you are contracting for

Second, that you be able to limit the bidders to men of such reputation that you do not care which one of them gets the job.

Third, that the job shall not be so large as to extend over a period of time too long to assume that a contractor can with a fair degree of definiteness, predict both his labor and material conditions. My own idea is that the upper limit of the lump-sum contract according to that definition would be somewhere between a quarter and a half million dollars. For all work falling outside of these limits I would advocate a contract similar in principle to the emergency construction contract.

Discussion by Charles R. Gow.†—The war emergency contract is theoretically ideal for all classes of work requiring the services of a contractor. I say "theoretically ideal" only, because it is perfectly obvious that there are many difficulties of a practical nature which must be overcome before it can ever have universal application.

It is safe to assert, however, that under any other form of contract yet devised, the war construction program could not have been as successfully accomplished as was the case. The army had a vast amount of construction work to do which, to meet requirements, necessitated completion within a period of unprecedented briefness. By means of this form of contract it was possible to select the contractor and get him on to the site even before the general plans were completely outlined. The Government retained, throughout the progress of the work, entire control of operations, directing the contractor's methods and procedures whenever necessity required, changing plans, adding or omitting work, suspending operations in whole or in part, dictating labor or other policies and exercising, at its option, any function ordinarily delegated to the contractor, whenever changing conditions or events rendered such action desirable.

The Government received in return the expert services, ability, experience and special qualifications of the contractor; the use of a trained organization skilled in the particular line of work contemplated and possessing a thorough knowledge of procedure, which resulted in the adoption of the most direct methods for prompt and economical completion. For this special character of service which the contractor brought to the Government's aid, a fee was paid, differing slightly, if at all, in its value from that paid to the engineer or architect for his particular expert service in the conception and design of the project.

In other words, the contractor was employed upon a professional rather than a commercial basis and his relationship was one of adviser and assistant to the owner, rather than an agent to carry out a specific detailed and inflexible agreement.

Under this form of contract the contractor is relieved from practically all financial risks and is reimbursed for the actual cost of operations as the work proceeds. While the maximum fee of $250,000, allowed under the war emergency contract, appears generous in amount, it is so only because of the magnitude of the work involved. In the case of the Boston Army Supply Base which has come under my immediate supervision, the estimated cost was $28,000,000. Upon the expenditure of the first $10,000,000 the contractor had earned the maximum allowable fee of $250,000, and was required to complete the remaining $18,000,000 of work without further profit. It is now known that the final cost will not reach the expected total, but assuming that it did, this fee would be equivalent to less than 1 per cent on the cost of the work. As no reimbursement is made for cost of financing certain overhead and legal expenses, this percentage will be further reduced and, after allowing for the Government excess profits tax, the net return to the contractor will be less than one-half of one per cent, certainly a very low rate for the valuable services rendered.

It will undoubtedly be argued by many that the average contractor cannot be trusted to give economical and honest services to the owner, unless held to some strict financial accountability. The reason for this suspicion is largely an outgrowth of experience with the lump-sum type of contract.

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wherein the owner and contractor gamble on the probable cost of the work. I realize that the owner, at least, will not exactly relish the appellation of gambler, but it cannot be successfully denied that the ordinary lump-sum contract contains several elements of chance, both for the owner and the contractor. The owner usually hopes to escape the burdens of many of the uncertain features in his work, and to this end insists that the contractor shall assume them. He invites competition in the hope that he may thereby receive a low figure for the work, knowing full well that the low bidder is accepting the chances of financial failure which the hidden uncertainties may bring. This is fair enough, in a way, since the contractor accepts the conditions as outlined for him by the owner, but to this extent the cards are stacked against him and he realizes it. He must, therefore, possess the gambling instinct and be convinced that he is a better player at the game of chance than is the owner, otherwise he must lose. He attempts to match his cleverness, in devising methods for overcoming the handicap laid against him, in opposition to the shrewdness of the owner who has drawn an intended iron-clad contract aimed to prevent advantage being taken of any possible loophole.

The two parties are thus put in antagonistic positions toward one another from the first, each seeking to prevent the other from gaining at his expense. Under such circumstances there can be no mutual regard for the interests of the two parties. If the owner has inadvertently omitted to cover a contingency which unexpectedly arises, the contractor cannot be blamed if he demands a strict financial adjustment of the consequent expense because he realizes that had the particular contingency fallen under some blanket provision of the contract, he would have to accept the resultant loss, with only the owner's sympathy to comfort him.

In the last analysis, neither owner nor contractor gains materially from this form of relationship. If an occasional owner succeeds in having his work done at less than actual cost or at a very low margin of profit to the contractor, there are many more instances in which, if the contractor does not realize an excessive profit, the owner still loses by reason of inferior workmanship, delays in completion or expensive lawsuits. On the other hand, while a contractor frequently obtains an exorbitant rate of profit for his work, his average earnings over a series of years are apt, generally speaking, to be disappointingly small. A brief review of the list of contractors whom any one of us have known will soon demonstrate the fact that very few have retired from their business wealthy.

I realize that many of you engineers, and probably an equal number of my contractor friends, will disagree with my analysis, and defend the lump-sum form of contract as offering superior advantages according to your viewpoints, but you cannot successfully deny that this type of contract has produced about as much, if not more dissension, than any other existing business relationship. Because of the gambling nature of the transaction, there is a mutual feeling of distrust between the contracting parties. Each party generally watches the other closely because he realizes that a premium has been placed upon dishonesty. Only in exceptional cases does the contractor concern himself with the owner's welfare, and then usually for shrewd business reasons. Occasionally, also, an owner may be found who is desirous that the contractor shall not suffer financial loss on account of his contract, but such owners are now generally committed to some form of the fee type of contract.

Before the fee type of contract can become universal, it will be necessary for both parties to alter materially their conception of responsibility. On the one hand, the owner must be brought to understand that the work is being done primarily for his benefit and that therefore he has no moral right to evade full payment for every feature of the undertaking, both known and unknown. It is his object to accomplish something which he is unable to do himself, because it demands training and skill which only an experienced and competent contractor can supply. There can be no valid objections, therefore, to the employment of a carefully selected contractor in whom the owner has confidence and who has demonstrated, in previous cases, his ability to satisfy his clients.

On the other hand, the contractor must come to appreciate the fact that only by establishing a reputation for honest, conscientious effort to promote the interests of his employer, can he expect to succeed in business With a positive profit assured him in advance, he will be justified in accepting a much lower rate of return than is now required, to offset his frequent losses. He must be educated to the fact that his continued employment in his chosen line depends upon the economic and workmanlike results which he produces and that his interests and those of the owner are identical, so far as these features are concerned.

Whether this result can ever be obtained with the class of contractors produced by the lump-sum method of contracting, may be subject to some question, but, undoubtedly, an evolution is already taking place and there is a gradual growth in tendency, in most large communities in this country, toward a recognition of these principles on the part of certain contractors and owners.

It seems to me altogether probable that a further extension of effort in this direction will result in an approach toward perfection of detail and that the time may yet arrive when the contractors will generally be employed only because of their recognized fitness for the work to be done any for their reputation for honesty, economy and dependability in a business way, rather than because they are willing to take a gambler's chance of winning or losing on the basis of a lump-sum bid with the cards stacked against them.

Discussion by William F. Kearns.[‡]—I am glad of the opportunity which is now afforded me to endorse all that Major Gow has said regarding the cost-plus contract. In the past I have been an ardent advocate of the lump-sum form of contract, but I have been converted during the last few years and I am now thoroughly convinced that the cost-plus is really the better proposition. It is certainly the more honest form, eliminating as it does that element of chance which is always present in the lum-sum contract. I do not think a more equitable form of contract ever has been devised. I hope it will soon be adopted generally, and it is going to be my aim to see that it is put into use wherever possible, both in private and public work.

Discussion by Charles T. Main.[**].—I can add very little to what General Marshall has said in connection with the cost-plus contract. When the form of contract was criticized by some Congressmen, I had the honor to be appointed on the commission to look into the form of contract and to report as to its advisability.

We sat for three days, and very carefully discussed every phase, every feature of all forms of contracts, and of any other method of conducting work of this sort, and the conclusions which the commission reached have been given to you by General Marshall. We were unanimous in the opinion that under the circumstances existing no other form of contract could be used.

Up to within 10 or 15 years, I with all other engineers, used the lump form of contract, and we thought we used it with very good success. In those days the prices of materials and labor were not so unstabilized as they are at present, and wherever the conditions were definitely defined and we could make definite plans and write definite specifications, we thought, and I think contractors thought, that everybody was getting a square deal.

I know that one contractor thought that he was not a gambler when he was bidding on our plans, because he told me there was no fun in bidding on them as there was no guessing to be done, they were so definite; and many of my clients up to this day are very much opposed to any other form of contract and are willing to expend sometimes several thousand dollars more than they might otherwise on another form of contract for the purpose of getting rid of the complicated accounting system which looks like a bugbear to them, and they are willing to pay a contractor perhaps $10,000 more on the lump sum to do a job and have it done in a clean-cut way and have nothing to bother about in the accounting.

I doubt perhaps if we ever, those of us who are the older members of the society, will see the conditions so stabilized that we will be able to get lump-sum contracts on very much of our work, and I believe myself that the best way, the fairest way, to conduct the work is to do it on a cost-plus basis, but I have got to educate some of my clients to make them see that. If conditions ever get stabilized again, I am sure we are going back in some of our work to lump-sum contracts.

[‡] Of W. F. Kearns Co., General Contractors for Boston Army Supply Base, Boston, Mass.

[**] Consulting Engineer, 201 Devonshire St., Boston, Mass.

I think also that perhaps if we get the right contractor, and there are a lot of them, and I hold them in the very highest respect, that it is better for the engineer to have that form of contract. It seems to me to make less trouble in many ways. There are some disadvantages to the other form.

I think that the workmen on the job soon know that the contract is not for a lump sum, that it is on a cost-plus or cost-percentage basis, and they begin to slacken up in their efforts, and there are other reasons why work does not proceed as economically as it would under the lump-sum form.

Wage Scale of St. Louis Building Trades

The following tabulation shows the wage scale on Sept. 1 last for various classes of labor employed in the building trades of St. Louis, Mo.:-

	Wages per hour or day.	Hours per day or week.	Overtime on week days.	Overtime on Sat., Sun. & holidays.
Boiler makers, inside	$0.70	48	1½	2
Boiler makers, helpers	.50	48	1½	2
Boiler makers, outside	.80	8	1½	2
Boiler makers, helpers	.55	8	1½	2
Bricklayers	1.00	8	2	2
*Carpenters	.87½	8	2	2
*Carpenters, helpers	.50	8	2	2
*Cement finishers	.82½	8	1½	2
*Concreters	.60	8	1½	2
*Concreters, blockmen	.65	8	1½	2
Electricians	1.00	8	2	2
Electricians, helper, first year	30	8	2	2
Electricians, helper, second year	40	8	2	2
Electricians, helper, third year	.50	8	2	2
Electricians, helper, fourth year	.60	8	2	2
Elevator constructors	.92½	8	2	2
Elevator constructors, helper	.62½	8	2	2
*Engineers, single hoist	.87½	8	1½	2
*Engineers, double hoist	1.00	8	1½	2
*Excavators	15	9	1½	2
Gas fitters	.75	8	2	2
Glaziers, putty	.62½	8	2	2
Hod carriers, brick	70	8	2	2
Hod carriers, mortar	.70	8	2	2
Hod carriers, plaster	.75	8	2	2
Iron erectors, ornamental	.92½	8	2	2
Iron erectors, helpers	.20-.45	8	1½	1½
*Iron erectors, structural	.92½	8	2	2
*Iron erectors, structural, helpers	40-.45	8	1½	1½
*Laborers, building	.50	8	1½	2
Lathers	.93¾	8	2	2
*Marble cutters	.38½-.50	52	1	1
Marble setters	.87½	8	1½	2
*Marble setters, helpers	.52½	8	1½	2
Millhands, non-union	.40-.65	8	1	1
Millhands, union	.52½	48	2	2
Millwrights	.87½	8	2	2
Millwrights, helpers	.50	8	1½	2
Painters	.75	8	2	2
Paperhangers	.85	8	2	2
Piledrivers	.80	8	1½	8
Pipe coverers	.80	8	1½	2
Pipe coverers, helpers	.54	8	1½	2
*Plasterers	1.00	8	2	2
Plumbers	1.00	8	2	2
Plumbers, laborers	.62½	8	2	2
*Roofers, gravel and composition	.70	8	1½	2
*Roofers, laborers	.40-.50	8	1½	2
Roofers, slate and tile	.87½	8	1½	2
Sheet metal workers	.80	8	1½	2
Sheet metal workers, helpers	.20-.45	47	1	1
Sprinkler fitters	.81¼	8	2	2
Sprinkler fitters, helpers	.50	8	2	2
Steamfitters	1.00	8	2	2
Steamfitters, helpers	.56¼	8	2	2
Stonecutters	.85	8	1½	2
Stonecutters, helpers	.60	8	1½	2
Stonemasons	.85	8	1½	2
Stonemasons, helpers	.60	8	1½	2
Tile setters	.85	8	1½	2
Tile setters	.87½	8	1½	2
*Tile setters, helpers	.52½	8	1½	2
*Wreckers	.38½	9	1½	2

*Indicates demand for increase in wages.

Employment-Management Course at Canadian College.—The University of Toronto during September gave a short course in employment management. Instruction was given daily, except Saturdays. The course fell into three divisions—personal management, industrial psychology, and economic principles and methods. Two of the lecturers were Lieut. Col. John J. Coss, of Columbia University, and a member of the War Industries Board of the United States, and Dr. E. K. Strong, of the Carnegie Institute of Technology (Pittsburgh), and a member of the committee on the classification of personnel in the United States Army. If the university authorities find that the results of the experimental course justify the efforts which have been made, it is probable that similar courses will be instituted in the future.

Concreting in Cold Weather

By A. E. WELLS,

President, Wells Brothers Construction Co.

Winter work is not new. It has been practiced for years, its safety adequately demonstrated, its economy proved. It should be more generally practiced. Any owner who, through prosecuting work during cold weather, can get occupancy of factory or warehouse or can lease apartments, offices or store space on May 1, stands to gain far more than the added costs of winter work.

Not only the owner, but builder, engineer and architect, gain. There is financial loss to the contractor who breaks up his trained organization, only to build it again in the spring. New men must take time to accustom themselves to working together and owners pay the bill in increased costs. Architects' and engineers' offices are frequently idle through much of the winter. Building superintendents have nothing to do and owners pay for unproductive overhead.

Perhaps the best way to reduce the cost of building is to keep architects', engineers' and contractors' forces busy 12 months of the year.

Primarily the reason why building has been inactive in cold weather months is that concrete does not harden so rapidly when the temperature hovers near freezing. But we heat our homes, offices and stores and coal is a comparatively small operating cost. We are today able to enclose a structure, warm it with simple coke stoves, heat aggregates prior to mixing with Portland cement, and keep the concrete or mortar warm until hardening has occurred.

Without these precautions, cold weather work is impossible, but the precautions are simple and reasonably inexpensive. Why not do the logical thing and consider the winter as an open season for all but the most exposed class of construction.

Our organization has continued to lay brick and place concrete under zero temperatures even in the northern cities of Canada. A part of our normal equipment is sufficient tarpaulins to enclose practically any structure and sufficient salamanders or coke stoves to keep such enclosures warm. Boilers of any type, frequently those used to furnish steam for hoisting, supply live steam for heating aggregates and water and for thawing snow and ice from forms and reinforcing steel.

While a heavy snow may temporarily delay the delivery of materials, yet deep snow is seldom encountered. It is temperature alone that commonly hampers work, and temperature need not be feared.

In laying out a plant for handling concrete in winter, or where the work is likely to run on into the winter before completion, there must be provision for the proper heating of materials and water. In case of sand and gravel in open storage piles, it is only necessary to lay a grid of steam pipes under the material piles and place a tarpaulin over the pile. From one main through the center, branches should extend in both directions every 6 ft. These branches should be drilled with ⅛-in. holes spaced about 18 in. apart. Several hundred yards of material stored in one pile can be heated in this way with the steam from an ordinary hoisting boiler. Several days prior to concreting, steam should be turned into the pile during working hours which will be sufficient, except at times of extreme cold, to maintain the necessary temperature.

When material is stored in bins, a series of pipes should be laid on the floor of the bins, feeding from a main pipe at the top of the sloping floor. Steam radiates through the entire contents of the bin and if a canvas cover is pulled over the top when work is stopped at night, the material will retain its heat, except in very cold weather, when a small amount of steam may be needed at night.

It is necessary also to heat mixing water and a steam line running directly into the water tank is the customary way; a 1-in. line being sufficient to heat water for a 1 yd mixer.

But concrete poured into forms exposed to cold would lose its heat before hardening had progressed sufficiently. Forms must therefore be protected and a satisfactory means is a complete canvas enclosure, with salamanders or coke stoves to maintain a temperature of 45° or over, within. Several hours before concrete is poured, salamanders are started in the story below the forms, unless that story is already heated. Immediately after pouring, a sufficient number of salamanders are placed above the new concrete to insure its safe and thorough hardening. These will furnish heat for the floor above.

This method of enclosure and heating necessitates that the form work for the floor above that being poured shall be in place, in order to serve as a roof under which concrete may be kept warm; although in the case of steel frame structure, it may be possible to support canvas upon the steel because of the floor above.

Forms for the story above are supported as usual, upon posts, but since the floor slab of the story supporting these posts is not yet poured, it is customary to set the posts upon concrete blocks of the proper depth so that upon pouring, the block becomes a part of the finished floor. This requires setting blocks to grade and finishing their upper surface.

It is of course, necessary that the workmen be watched somewhat more carefully on winter work. Snow or ice in the forms is detrimental to good work. Careful inspection is necessary at every stage of the work, but slipshod methods are probably no more likely to effect quality in winter than in summer.

Where the enclosure in canvas is comparatively complete, workers operate at practically normal efficiency, but there are some delays likely to occur through slow delivery of materials during periods of snow. Yet the added costs are more than compensated for by the certainty of quicker occupancy and reduction of interest on money tied up in the incompleted building. It would seem folly to cease work on a structure where there is need of early use.

Business Training for the Engineer and Engineering Training for Commercial Enterprises

The following recommendations of F. L. Bishop, dean of the School of Engineering of the University of Pittsburgh, as to the new types of engineers required and the training that should be given each type are of interest:

"The first type is that of the man who may be called a technician, who is highly trained in science and mathematics, who possesses the instinct of the research man and who can devote his entire time to highly technical research problems, either in the research laboratories which are now rapidly being developed in the large industries, or by applying the results of his research to engineering science. For the training of this type of man, there is needed the best of scientific equipment, the members of the faculty must be those who are intimately interested in research problems, and the student himself must have what is sometimes called a mathematical mind. It is doubtful if this type of man can be developed in a 4-year course under existing conditions. In fact, it is probable that such a man can be developed only in a school which has a thorough graduate department.

"The second type which seems to be demanded by the industries is the man who has a broad general knowledge of engineering subjects and can apply that knowledge in an effective way in present engineering problems. He must have ability to command men, a knowledge of the applications of economic principles to industries, and a broad training in the so-called humanities, since he is the man in contact with men of other types in other fields of human activities. He should not be a research man, his training in mathematics need not be of necessity so extensive as that of the research technician, but his understanding of engineering problems should be extensive. Such a man cannot be trained in the ordinary schools because of the artificial conditions which of necessity exist in academic institutions. He must become familiar with the industries while yet a student in order that he may understand thoroughly the application of his theoretical courses in school and their application to industries, and also that he may become familiar in the formative period of life with the problems of labor and the human factor in engineering. It is in the development of this type of man, who is to become the manager and operating head of our large manufacturing industries, that the advantages to be derived from the co-operative system of engineering education are needed."

Principles Governing the Employment Relation in Industry

The Employers' Group of the National Industrial Conference, now in session in Washington, on Oct. 10 submitted the following statement of the principles which in its opinion should govern the relationship between employers and labor:

Sound industrial development must have as its foundation productive efficiency, and high productive efficiency requires not only energy, loyalty and intelligence on the part of management and men, but sincere co-operation in the employment relation based upon mutual confidence and sympathy.

This is true of all producing industries, large and small, of the farming industry as well as the manufacturing. While there are differences between the different branches of industry which call for special application of the underlying principles, these principles are the same in all.

Without efficiency in production, that is to say without a large product economicaly produced, there will be no fund for the payment of adequate compensation for labor, management and capital, and high cost of living will inevitably continue. Moreover, without such efficiency it will be impossible for American industry successfully to compete in foreign markets or with foreign competition in this country. The larger and more effective the production, the greater will be the return to all engaged in the industry, and the lower the cost of living.

The requisite efficiency in production cannot be secured unless there is effective co-operation between employer and employe, such as is only possible where, with a full understanding of each other's point of view, management and men meet upon a common ground of principle and in a spirit of co-operation based upon good understanding and a recognition of what is fair and right between the two. Then only can there be that harmony which will insure the prosperity of those engaged in industry and of all the people.

With full recognition of the vital importance of these conditions and with due realization of the great responsibility resting upon management to secure their practical application in industrial affairs, we submit the following principles which we regard as fundamentally sound in the interest of industry, of those employed or concerned in industry, and of the people as a whole.

1. **Production.**—The industrial organization as a productive agency is an association of management, capital and labor voluntarily established for economic production through co-operative effort. It is the function of management to co-ordinate and direct capital and labor for the joint benefit of all parties concerned and in the interest of the consumer and of the community. No employment relation can be satisfactory or fulfill its function for the common good, which does not encourage and require management and men to recognize a joint as well as an individual obligation to improve and increase the quantity and quality of production to as great an extent as possible, consistent with the health and well-being of the workers.

There should be no intentional restriction of productive effort or output by either the employer or the employe to create an artificial scarcity of the product or of labor in order to increase prices or wages; nor should there be any waste of the productive capacity of industry through the employment of unnecessary labor or inefficient management.

It is the duty of management on the farms and in industry and commerce, as far as possible, to procure the capital necessary for the increased production that is required, and of both management and labor to co-operate to promote the use of capital in the most efficient fashion.

2. **The Establishment as a Productive Unit.**—Recognizing the co-operative relationship between management and men essential to productive efficiency as a prerequisite for national and individual well-being, the establishment rather than the industry as a whole or any branch of it should, as far as practicable, be considered as the unit of production and of mutual interest on the part of employer and employe. Here, by experimentation and adaptation, should be worked out and set up satisfactory means for co-operative relations in the operation of the establishment, with due regard to local factors.

Each establishment should develop contact and full opportunity for interchange of view betwen management and men, through individual or collective dealing or a combination of both, or by some other effective method, always predicated on both sides on honesty of purpose, fairness of attitude and due recognition of the joint interest and obligation in the common enterprise in which they are engaged.

Mere machinery is not enough for this purpose. There must also be sympathy and good will with earnest intent that, whatever the means employed, they must be effective.

3. **Conditions of Work.**—It is the duty of management to make certain that the conditions under which work is carried on are as safe and as satisfactory to the workers as the nature of the business reasonably permits. Every effort should be made to maintain steady employment of the workers both on their account and to increase efficiency. Each establishment should study carefully the causes of unemployment and individually and in co-operation with other establishments in the same and other industries should endeavor to determine and to maintain conditions and business methods which will result in the greatest possible stability in the employment relation.

4. **Wages.**—While the law of supply and demand must inevitably play a large part in determining the wages in any industry or in any establishment at any particular time, other conditions must be taken into account such as the efficiency of the worker and the wage standard of the industry in the locality. The wage should be so adjusted as to promote the maximum incentive consistent with health and well-being and the full exercise of individual skill and effort. Moreover, the business in each establishment and generally in industry should be so conducted that the worker should receive a wage sufficient to maintain him and his family at a standard of living that should be satisfactory to a right-minded man in view of the prevailing cost of living, which should fairly recognize the quantity and quality of his productive effort and the value and length of his service, and reflect a participation on his part in the prosperity of the enterprise to which he is devoting his energy.

Many plans are now under consideration for adding to the fixed wage of the worker such, for example, as bonus payments, profit sharing and stock ownership. All such plans should be carefully studied in each establishment. It may well be that in many instances the employer and the employe could work out an arrangement of such a character to their mutual advantage.

In order that the worker may in his own and the general interest develop his full earning capacity and command his maximum wage, it should be a primary concern of management to assist him to secure employment suited to his abilities, to furnish him incentive and opportunity for improvement, to provide proper safeguards for his health and safety, and to aid him to increase the value of his productive effort.

Where women are doing work equal with that of men under the same conditions, they should receive the same rates of pay as men and should be accorded the same opportunities for training and advancement.

5. **Hours of Work.**—Hours of work schedules should be fixed at the point consistent with the health of the worker and his right to an adequate period of leisure for rest, recreation, home life and self-development. To the extent that the work schedule is shortened beyond this point the worker as well as the community must inevitably pay in the form of a reduced standard of living.

The standard of the work schedule should be the week, varying as the peculiar requirements of individual industries may demand. Overtime work should, as far as possible, be avoided, and one day of rest in seven should be provided.

6. **Settlement of Disputes.**—Each establishment should provide adequate means for the discussion of all questions and the just and prompt settlement of all disputes that arise between management and men in the course of industrial operation, but there should be no improper limitation or impairment of the exercise by management of its essential function of judgment and direction.

7. **Right to Associate.**—All men have the right to associate voluntarily for the accomplishment of lawful purposes by lawful means. The association of men, whether of employers, employes or others, for collective action or dealing confers no authority and involves no right of compulsion over those who do not desire to act or deal with them as an association. The arbitrary use of such collective power to coerce or control others without their consent is an infringement of personal liberty and a menace to the institutions of a free people.

8. **Responsibility of Associations.**—The public welfare requires that there shall be no exercise of power without corresponding responsibility. Every association, whether of employers or employes, must be equally subject to public authority and legally answerable for its own conduct or that of its agents.

9. **Freedom of Contract.**—With the right to associate recognized, the fundamental principle of individual freedom demands that every person must be free to engage in any lawful occupation or enter into any lawful contract as an employer or an employe, and be secure in the continuity and rewards of his effort.

The only qualification to which such liberty of contract is subject lies in the power of the state, within limits imposed by the Constitution, to regulate in the public interest, for example, for the promotion of health, safety and morals.

10. **The Open Shop.**—The principles of individual liberty and freedom of contract upon which our institutions are fundamentally based require that there should be no interference with the "open shop," that is, the shop in which membership or non-membership in any association is not made a condition of employment. While fair argument and persuasion are permissible, coercive methods aimed at turning the "open shop" into a "closed union" or "closed non-union shop" should not be tolerated.

There should be no denial of the right of an employer and his workers voluntarily to agree that their relation shall be that of the "closed union shop" or of the "closed non-union shop." But the right of the employer and his men to continue their relations on the principle of the "open shop" should not be denied or questioned. No employer should be required to deal with men or groups of men who are not his employes or chosen by and from among them.

Under the organization of the "open shop" there is not the same opportunity for outside interference on the part of other interests to prevent close and harmonious relations between employer and employe. Their efforts to continue or secure such harmonious relationship are not complicated to the same extent by intervention of an outside interest which may have aspirations and plans of its own to promote, which are not necessarily consistent with good relations in the shop.

11. **The Right to Strike or Lockout.**—In the statement of the principle that should govern as to the right to strike or lockout, a sharp distinction should be drawn between the employment relations in the field (a) of the private industry, (b) of the public utility service, and (c) of Government employment, Federal, state or municipal. In all three there are common rights and obligations, but, insofar as the right to strike or lockout is concerned, the nature of the Government service and public utility operations requires that they should be considered from a somewhat different point of view than private industry.

In private industry the strike or the lockout is to be deplored, but the right to strike or lockout should not be denied as an ultimate resort after all possible means of adjustment have been exhausted. Both employers and employes should recognize the seriousness of such action and should be held to a high responsibility for the same.

The statement that the right to strike or lockout should not be denied, does not cover the matter of the sympathetic strike or lockout, where for mere purposes of coercion there is a combination deliberately inflicting injury upon parties against whom the assailants have no grievance, for the purpose of accomplishing an ulterior result. The sympathetic strike is indefensible, anti-social and immoral. The same may be said of the blacklist, the boycott and also of the sympathetic lockout.

In public utility service the public interest and welfare must be the paramount and controlling consideration. Modern social life demands the uninterrupted and unimpaired operation of such service, upon which individuals and communities are as dependent as is human life on the uninterrupted circulation of the blood. The state should, therefore, impose such regulations as will assure continuous operation, at the same time providing adequate means for the prompt hearing and adjustment of complaints and disputes.

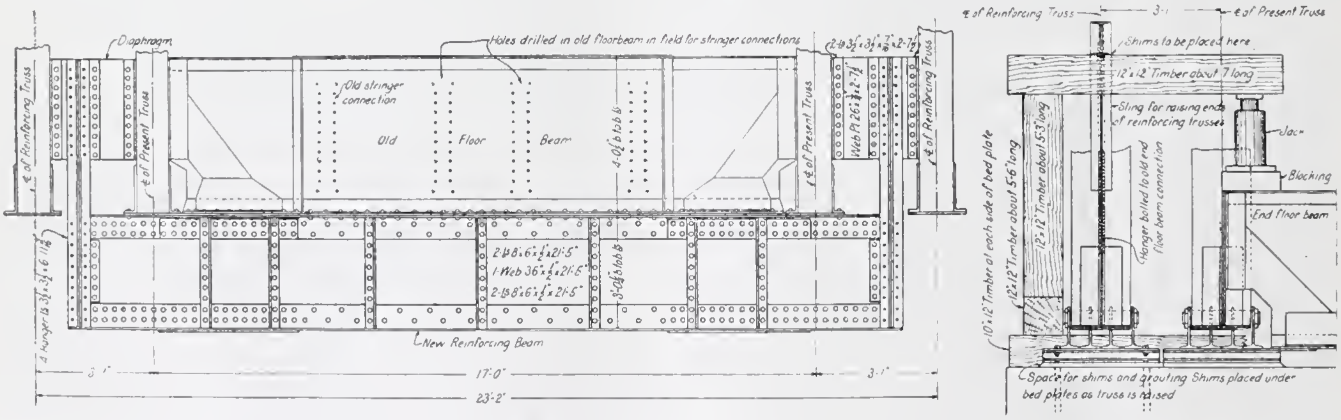
In Government employment the orderly and continuous administration of governmental activities is imperative. A strike of Government employes is an attempt to prevent the operation of Government until the demands of such employes are granted, and cannot be tolerated. No public servant can obey two masters; he cannot divide his allegiance between the Government which he serves and a private organization which, under any circumstances, might obligate him to suspend his duties, or agree to assist him moraly or financially if he does. Social self-defense demands that no combination to prevent the operation of Government be permitted. The right of Government employes to be heard and to secure just redress should be amply safeguarded.

12. **Training.**—Practical plans should be inaugurated in industry and outside of it for the training and upgrading of industrial workers, their proper placement in industry, the adoption and adaptation of apprenticeship systems, the extension of vocational education and such other adjustments of our educational system to the needs of industry as will prepare the worker for more effective and profitable service to society and to himself.

The foregoing is limited to a statement of principles. Only casual reference has been made to methods by which such principles may be carried into effect. The problems are so serious and difficult that such methods must be worked out by the individual establishments in conjunction with their employes and by industry as a whole.

Strengthening Old Bridges by Doubling Up the Trusses

During the latter part of 1918 two 100-ft. single track railway spans on the Kansas City Southern R. R. were reinforced for modern standard loading by adding extra trusses and stringers from like spans which had previously been taken out of service. The spans recently reinforced are in two different bridges and had been continued in service for some years under traffic much in excess of the loads for which they were designed by maintaining slow orders. Formerly there were a number of spans of this type on the road, but all had been removed except these remaining two. They are through pin-connected spans, of the so-called A-truss type, with four 25-ft. panels. The method of handling this work was described by Mr. E. E. Howard, Consulting Engineer, Kansas City, Mo., in the Railway Age, from which the matter following is taken.


Diaphragm
Holes drilled in old floorbeam in field for stringer connections
Old stringer connection
Old Floor Beam
4-0⅝ b to b
℄ of Reinforcing Truss
℄ of Present Truss
2-⌞s 3½"×3½"×7/16"×2'-7½"
Web Pl 26"×⅜"×2'-7½"
℄ of Present Truss
℄ of Reinforcing Truss
4 Hanger ⌞s 3½"×3½"×6'-11⅛"
2-⌞s 8"×6"×½"×21'-5"
1-Web 36"×½"×21'-5"
2-⌞s 8"×6"×½"×21'-5"
3'-0⅝ b to b
New Reinforcing Beam
3'-1"
17'-0"
3'-1"
23'-2"
℄ of Reinforcing Truss
3'-1"
℄ of Present Truss
Shims to be placed here
12"×12" Timber about 7' long
Sling for raising ends of reinforcing trusses
Jack
Blocking
End floor beam
10"×12" Timber at each side of bed plate
12"×12" Timber about 5'-6" long
12"×12" Timber about 5'-3" long
Hanger bolted to old end floor beam connection
Space for shims and grouting Shims placed under bed plates as truss is raised

Manner of Reinforcing Old Floor Beams With Beams Hung From Both Old and New Trusses and Method of Lifting the Ends of the New Truss.

It developed that several of the old spans were still stored in the yards and were available for use and that the metal of the old spans in position and that in storage was in good condition. Estimates were made for replacing one of the spans with two 50-ft. deck girders, building one new pier, and for replacing the span of the other bridge with a truss span designed for present loading. The scheme was also devised of strengthening the old spans by the use of the metal of the similar spans held in storage, and this was adopted.

The reinforced spans are ample for Class E-55 loading and the additional material was added without interruption to traffic. The required modification of the substructure was slight, no changes in the old spans were necessary except for the connection of new metal, and the total additional new metal required was only about 15 tons per span. This method was especially advantageous in view of the difficulty of securing new structural metal work in the summer of 1918, while the money outlay was considerably less than that required for all new material.

The added trusses are set outside the existing trusses at 3 ft. 1 in. centers. Diaphragms connect the pairs of trusses at the three intermediate panel points and support the floor beams. The trusses are also connected by occasional batten plates. A new floor beam was placed underneath each existing intermediate floor beam and riveted to its lower flange, forming a composite beam. The new beams extend out and hangers from their ends connect to the diaghragms joining the trusses. The stringers in the existing spans were 8 ft. center to center. Extra stringers 2 ft. center to center were put in between them to divide the track loads.

The end floor beams were not reinforced, but the piers were built up, and special shoes provided to support the ends of the two middle springers. The lower lateral system was somewhat modified so that connection was made to the new stringers as well as the two original ones.

The erection was very simple and required no falsework. The piers were first cut down a distance of about 5 ft. and built up in reinforced concrete, with the ends extended sufficiently to provide seats for the shoes of the new outside trusses. These reinforcing trusses were erected by suspending them from the existing span and the new floor beams were similarly swung in place and supported. After connections at the intermediate points had been made, the ends of the added trusses were jacked up, and suitable shim plates placed under the end shoes to subject the new trusses to enough deformation so that they would take their share of the load. Careful distortion measurements made after the reinforcing of the spans was completed show satisfactory, although not exact, distribution of live load stresses, between the trusses at each side.

The work was carried out expeditiously and the completed structure, while somewhat unusual in appearance and rigid, substantial and of ample strength. The estimates of the cost for the bridge where two 50-ft. girder spans and one new piece could have been used, was about $11,000 for new construction throughout, and about $8,000 for the reinforcing of the existing span. For the bridge where a 100-ft. opening had to be maintained, the cost of a new bridge throughout was about $19,000 and of the reconstruction with four trusses, about $7,500. These figures represent the cash outlay, without allowance for the amount the railroad charged itself for the old metal stored in the yards, nor for the salvage value of the old spans had they been removed. The total cash outlay, therefore, was cut down from $30,000 to about $15,000—a matter of some importance during the wartime conditions.

The scheme for the work was devised and the plans prepared by Harrington, Howard & Ash, Consulting Engineers, Kansas City. The work was carried out by the Kansas City Bridge Co., all under the direction of J. M. Weir, Chief Engineer, Kansas City Southern Ry., Kansas City.

New Engineering School in Pennsylvania.—As part of its movement in the field of industrial research the Carnegie Institute of Technology has announced that a new engineering school will be established in Pennsylvania. The school will be under the direction of the Institute, the U. S. Bureau of Mines and the coal operators of the Pittsburgh District.

Measures for Preventing Accidents in Building Construction*

By F. J. C. DRESSER,
The Austin Co., Industrial Engineers and Builders, Cleveland, O.

It is only in recent years that any discussions whatsoever have been had in reference to the hazards of building construction, and aside from statistics issued by the several insurance companies, no organized effort was made by the contracters generally to exchange ideas toward the elimination of accidents. However, the present day finds that several of the larger contracting organizations include a so-called bureau of safety, and their results have shown a remarkable reduction in the number of accidents, as well as an immense saving of lost time and money.

Development of a Safety Campaign.—In order to develop a proper safety campaign for the particular job in hand, an analysis is necessary, for the work itself is suggestive of the major portion, or rather kind, of possible accidents you will be obliged to combat. I do not mean to say that you can immediately eliminate all accidents, but certainly a study of former accidents on a similar piece of work will help greatly in a reduction of accidents on future work. To just such work, namely, analysis and issuance of instructions, is a safety bureau dedicated.

Of course, there are and always will be special pieces of work that must be accomplished which are different than any former, but I still maintain that the same fundamentals apply and that an analysis still can be made and preventive measures applied.

It is evident that the sewer or grading contractor, for instance, can, by a series of test holes, determine the character of soil he is obliged to excavate, and plan his working methods accordingly. Such procedure will tell him quickly what he must provide in the way of equipment and protective measures, and has the further advantage of not catching him unawares as far as unforeseen ground conditions are concerned.

The present day of multiple-story buildings, when radical changes in their construction methods are being employed, finds us facing the source of the greatest number of accidents, as is attested by the high insurance rates. Usually the public comes in for consideration, as far as safety methods are concerned, and in fact no other class of structure requires more consistent planning or forethought as regards accident prevention, unless it be in the tunnel or subway work as installed in our larger cities. For this work it is plain that proper and substantial equipment must be provided that possesses a good safe factor; the sidewalks and streets must be covered; riding loads and in hoists must be forbidden; stairways and ladders must be liberally provided; mechanical safeguards installed; rapidly moving load lines and signal cords boxed or otherwise protected; safety belts and scaffolds provided, and even a man's clothing must receive attention, for many a man has lost a hand by reason of his wearing a gauntlet glove, and others have lost arms and life because of a loose sleeve or glove which dangled into involving drums, or shafting, or which were caught by a broken strand in a cable.

Heavy foundation work requires the same care in accident prevention study, both in bridge and building work.

Pile driving is another hazardous piece of work, where moving timbers and lines are responsible for many avoidable accidents.

Wrecking and underpinning are other sources of accidents, and more numerous undoubtedly than should be because they do not receive the attention of an engineer as regards a plan, or, in other words, the average wrecking contractor does not have a staff or an engineer in his service who would calculate before doing work. As a result, defective material is often used and insufficient underpinning installed, causing accidents, of course.

Heavy rock excavation requires care in handling dynamite, precaution against flying rock and destruction of property.

Industrial building work is the source of possibly the greatest variety of accidents, but usually not as disastrous to life and limb as the previously mentioned class of work.

However, an analytical study in the direction of safety, no matter what the class of work, will certainly produce results if undertaken with the same spirit that a constructive engineer plans his layout and schedule.

Application of Safety Methods Depends on Employe.—The more intelligent the workman the less liable is he to accident. In this respect the ironworker or steel erector is possibly the most versatile in that he thinks of the possibilities of things happening in connection with the work in hand and is not so easily caught unawares. The brickmason and carpenter are usually on more substantial footing and inasmuch as their work is usually more regular, do not have occasion to give "Possible Happenings" much thought. No other mechanic possibly should possess good judgment any more than the hoisting engineer, especially be he engaged on multiple-story building work or heavy bridge construction. The common laborer, however, requires more watching than the trade mechanics, and in this respect much depends on the intelligence of the foreman who directs his movements.

All workmen, however, can be schooled in safety methods, as has been demonstrated by leading contracting companies who have safety bureaus. For instance, the Fred. T. Ley Co. began this work in 1915, and their reduction in accident rate per 1,000 employes for 1916 was 25 per cent, and in 1917 was 55 per cent, which is indeed encouraging.

Character of Accidents.—Our records, from a recent piece of construction, which involved steel erection, heavy concrete, brick work and grading, also track work, shows, from a total of 242 accidents, that: Seventy-three employes sustained bruised fingers from handling material; 37 employes sustained punctured feet from nails; 11 employes sustained cuts on head from falling material; 7 employes sustained sprained ankles, slipping and misstepping; 7 employes sustained cuts on hands, and the balance were minor injuries. This work comprised the erection of a large engine terminal, and this record conforms in the average to the class of accidents which we must safeguard against in the course of our regular standard industrial building construction.

I find in comparison with figures as derived by other concerns, that the accidents in the main are similar in character, but the percentages vary, due undoubtedly to the character of the work in hand.

The greatest number of accidents, we find, come during the handling of material, and are confined to hand injuries; second in number come injuries to feet from protruding nails; third, employes falling, by reason of misstepping or stumbling over strewn material, causing sprained and broken ankles, broken arms or legs; fourth, falling material, causing cuts about the body and broken limbs. These are the four main causes as we find them, and it is natural, therefore, that preventive measures be provided in the order named.

Measures for Preventing Accidents.—I believe it goes without question that a job properly planned, and scheduled whereby one phase of work closely follows the other, where material is received and handled in the same order and where orderliness prevails throughout, is rewarded by the least number of accidents.

Receiving of material and storing of same is a study in itself, for naturally the best position must be selected for hoists, and also for storing of material. One should be near the other to avoid rehandling and increased costs, also minimum handling reduces the possibility of accidents, as is plain. But often they are far apart, causing long runways to be built and arranged, in and out, around or through a building, as the case may be, creating a state of disorder and interfering with the other divisions of the work. The ideal, of course, is one where, for instance, structural steel can be placed from car to position, eliminating rehandling in field and on large operations where space is available, this can often be done with steel as well as other material, if hoists and material tracks or roads are given same attention as to layout and position before work is started in the field. The main object is to eliminate distance, for work is really distance versus resistance, as the definition goes, and the further application of all possible mechanical means to handle material from cars or wagon to position is another factor which results in a great reduction of accidents.

Our second consideration being given to nails, we find that orderliness in handling of lumber containing protruding nails, eliminates foot punctures by the score. Plank or forms of this character should be stacked with nails down and not be allowed to be strewn all over the job. In order to rouse the plank or board the carpenter must drive the nails back, and their removal as soon as the plan or brace is taken down is undoubtedly the best practice. As regards concrete form lumber that has been stripped, if it has no further use in the building as fabricated, it should be stacked and nails removed by the cleaning gang, is there is one, as soon as possible, to make it available for other use, for certainly the reuse of lumber these days is economy, and a carpenter usually will take a new piece rather than stop to remove nails. In a multiple-story concrete building, forms are usually stripped and immediately placed in position for the next floor, and the same applies to braces, so that the immediate removal or driving back of nails is necessary and foot punctures are made less possible, than on the ordinary timber or house job. Elimination of strewn lumber will reduce nail accidents and its reclamation should be taken in hand at once in order to make it fit for reuse, which in itself will cause a saving in the final lumber bill.

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*From a paper presented Oct. 2 before the Construction Section of the 8th Annual Safety Congress of the National Safety Council.

To avoid employes falling, railings should be erected on staging and scaffolds; runways of sufficient width provided, and material generally should not be strewn promiscuously about the job. Openings should be covered or railed and good staple ladders built. Climbing up or down hoist towers should be forbidden, and all moving lines boxed so as to avoid tripping. Working aisles should be kept clear of waste and surplus material.

To avoid falling material, storage of the same should be confined to the interior aisles, and scaffold provided with a side board to prevent brick especially from going over the edge.

In discharging debris, closed-in chutes should be installed, wheeling runways to be of sufficient width and overloading of wheelbarrows forbidden, especially when brick are being moved.

Results Obtained by Contractors' Safety Bureau.—Naturally the safety movement must begin with the management itself, and if contractors generally will review the results obtained by those contractors who do maintain safety bureaus, they will readily see that it is a paying branch of the organization. For instance, the following classification shows "Per cent reduction in the number of lost time accidents per 1,000 employes shown by years":

Per cent.	Classificaion of Accidents.	First year, 1915. Number of accidents per 1,000 employes.	Second year, 1916		Third year, 1917	
			Number of accidents per 1,000 employes.	Per cent reduction from 1915.	Number of accidents per 1,000 employes.	Per cent reduction from 1916.
18	Handling material	72	55	24	33	54
16	Falling material	63	35	44	16	75
15	Employes falling	61	43	20	28	54
8	Handling tools	22	28	12	13	59
20	Nails	80	71	11	42	47
3	Flying material	12	21	*75	9	25
6	Machines	24	9	62	6	75
14	Miscellaneous	55	41	25	33	40
100		399	303		180	

*Increase.

This table comprises some of the results obtained by the Fred. T. Ley Com., Mr. L. D. Von Woedkte being director of safety.

The results are plain, and inasmuch as the work covers only a period of three years, they are indicative of the immense amount of good work that can be done in accident prevention in general contracting, as propaganda of this kind is really in its infancy in this field.

Steps in an Accident Prevention Campaign.—The next step for an organization to undertake is the addition of a safety bureau, and under whose direction the work in itself is carried on. The first consideration must be given to the field organization itself, meaning the engineers, superintendents and in fact the entire rank and file, for co-operation must exist; and the foremen generally must see that the safety rules are observed.

As a further matter of co-operation, the construction department should turn over to the safety man, a complete schedule of the job in hand, showing the progress expected; this possibly being the first step. Second, a set of safety rules should be issued applying to the work or particular job in hand, which are set up after due analysis of the conditions which are to be met The third is, of course, the enforcement and application of these safety rules.

First of all, any job employing 125 men or more, dependent, of course, on character of the work and location, should have a first aid attendant and small field hospital. We find it pays decidedly—it eliminating lost time.

Second, the job organization should appreciate thoroughly the meaning of this safety work and they will in the end discover that lower unit costs will result in the observance of the safety rules first.

To educate the workmen themselves can be done in different ways, and first of all, I believe, he should be taught to observe safety rules provided as a precaution against the first or possibly the second classifications, which are most liable to happen. His education in this respect should be gradual or progressive as the work goes in, and his foreman, of course, should see that the rules are observed.

Descriptive photographs are an immense help in avoiding accidents and educational work, and should be kept in keeping with the class of work in hand.

Periodical bulletins help greatly, as do also signs which should be of such size and meaning as can be understood by all. A sign that can be read only a few feet distant is not of much use, it should be readable at a considerable distance, the farther, the better.

Another idea is to have progressive signs, or those which move forward with the work, cautioning what in particular may result from the work in hand at that time. These signs should be right on the job and not posted on the office door, which may be a mile away from the job.

These are, of course, just the means by which the idea can be conveyed, and various methods can be adopted as results may suggest; the same to be chosen by the safety director himself. In addition, safety meetings should be held on the job by the foremen and a plan of action or procedure decided upon before particular pieces of work are undertaken, also work covered should be reviewed, ideas exchanged and the work encouraged in every way. In this way the best methods can be secured.

Needless to say, the equipment for the particular job in hand should receive the same careful attention, first to be assured that it posseses the necessary safety factors to handle the work generally, and that it is in good repair at all times, and receives the necessary periodical inspection while on the work as well.

On all our work, for instance, we carry boiler insurance, they receive periodical inspection by the insurance company and, of course, must conform to the state laws in which they are put to use, otherwise no attempt whatsoever is made to use them.

Around the plant generally, guards should be built which will eliminate the possibility of employes coming in contact with the moving parts and lines, and the same consideration must be given to hoists and hoist lines. To operate plants efficiently requires good mechanics, of course, and a contractor who maintains a staff of experienced operators in connection with his organization has done much toward the application of safety methods, for the accident, as a rule, happens to the green man, no matter whether he be mechanic, laborer, or machine operator, and it is necessary to observe them very carefully, until such time as some experience has been gained.

Safety rules further will establish under what conditions a machine is to be operated and how, and will also establish signal codes to be observed, for very often the operator cannot see the other end of the line or top of the hoist, as the case may be.

At any rate, common sense application tells us that above all else you must have experienced machine operators, and none other should be permitted to be employed, yet many times you will find some man out of the gang running a machine, the principles of which are entirely foreign to his understanding.

The whole work, however, both as regards employes and equipment, is to be reviewed and inspected by the safety engineer, who will suggest precaution and safety rules.

Engineers Report on Reconstruction of New York State Government

Governor Alfred E. Smith, of New York, early in 1919, appointed a reconstruction commission to learn what could be done not only in physical construction, but also in reorganizing the state government for greater efficiency and economy. A part of the commission's organization is a staff of engineers. Engineering Council had previously appointed a reconstruction committee, and so when an invitation came to aid in the reconstruction work, the reconstruction committee selected a special advisory committee to the state of New York. Besides advising the reconstruction commission about public works which might be undertaken to advantage during the reconstruction period, this advisory committee was asked to study the engineering features of reconstruction of the state government. The following extracts from the report of the Advisory Engineering Committee indicate the scope of its studies and the conclusions reached:

In the matter of reorganization and consolidation of the existing state departments, boards and agencies, approximately 184 in number, and with respect to the establishment of a proper budget system for the state of New York, the advisory engineering committee appointed by Engineering Council has carefully considered the information placed before it.

The organization of the state government should secure two general results, namely, a policy responsive to public opinion and an efficient management of the business of the state. For policy, the governor, as chief executive, should be held responsible. Responsibility for efficient administration also should be definitely placed upon the governor. The governor should be given authority to put his views into effect, subject to necessary legislative action.

Consideration has been given to the question of a state manager, but it is concluded that the time is not yet ripe and will not be until the various departments, boards, commissions and other agencies are co-ordinated into a more orderly organization than now exists.

The governor should have a cabinet, or advisory council, consisting of the heads of departments appointed by him to aid him in co-ordinating and harmonizing the various functions of the state. A two-year term for the governor is too short, it should be four years.

State Budget.—At the earliest practicable date an effective state budget system should be installed in the interests of efficiency and economy. It is impracticable to establish a proper budget system unless co-ordination is provided for the existing departments, boards, commissions and other agencies created from time to time by legislative act. Under the present plan unsatisfactory performance appears inevitable, owing to division of powers, absence of initiative and lack of coordinated supervisory control with respect alike to policy, administration and disbursements. A successful budget system should provide some elasticity to permit efficient working, which is bound to be affected somewhat by elements beyond the control, in advance, of any official. Such elasticity should involve no waste of public funds, but should allow appropriations to be used to the best advantage of the state.

Department of Public Works.—The construction work of the state should be placed under a department of public works. This department would have a bureau of engineering, a bureau of architecture, a bureau of highways and a bureau of canal administration. Each bureau should have its own division of records and accounts, with the accounting standardized and audited by the state comptroller.

All new and large engineering and architectural projects should be handled by engineers and architects of wide experience and recognized standing, and the bureau of engineering and the bureau of architecture should do the routine work.

To permit engineering activities to be managed effectively adjustments should be made carefully, to guard against overlapping and lapses of jurisdiction, and recognition should be given the fundamental principles:

(a) No man in immediate charge of work should be given responsibility beyond what may be reasonably expected as regards the range of types of tasks which one man can look after with the aid of proper assistants.

(b) The organization as a whole should be such that the man in final authority, in respect to the policy, finances, labor, materials and other controlling factors can be [illegible] without delay by the man in immediate charge of any enterprise.

In the absence of such arrangements, difficulties are certain to arise, due to the non functioning of subordinates who have neither jurisdiction themselves nor ready access to those possessing authority. Lack of accessibility to the man in authority on the part of those actually managing detailed work, results in pigeonholing, with attending delay, erroneously assumed to be required by the red tape of Government formalities.

Other Departments and Boards. It is proper for the state department of health to have its own division of sanitary engineering, which should pass upon the reasonableness of all arrangements for the treatment of public water supplies, sewage and drainage. Matters of quality of public water supply should be under the jurisdiction of the state department of health, and matters of quantity and source of supply should be under the jurisdiction of the department of conservation.

Conservancy boards, sewage or drainage districts, and joint water districts, should be formed only in compliance with a well defined plan, and policy of the state, providing for the solution of local problems by local authorities, but with adequate protection of neighboring localities.

Some of the rivers of the state show objectionable defilement. Steps should be taken to keep these waterways clean by procedure which may be likened to street cleaning as conducted by local authorities. Local agencies for conducting river cleaning should be established under state regulations.

General Considerations.—As time progresses some of the elective officers may be dispensed with. If so, the eliminations could be effected by constitutional amendment and duties concentrated, either under these officers who are retained or under the proper departments.

Many consolidations of the bureaus can be made. Such consolidation would be in the line of simplification It is possible that some of the bureaus could be entirely abolished, without sacrifice of state efficiency.

Bureau heads and bureau organizations should be permanent, while all the department heads could be appointed by a new governor. Bureau heads could be removed on charges, but not necessarily changed every time a new administration takes office.

It is obvious that to insure efficient service and best results for the state, salaries should be adequate to secure officials fully qualified by ability and experience.

Blasting Out Concrete Column Inside a Building

Dynamite was employed in breaking up a 12 ft high, 4 ft square, concrete column in the cellar of a factory building at Batavia, N. Y. There was machinery on one side of the pier and machinery and windows directly above on the other side. In building the pier, the cement had been poured into forms in courses or tiers in the usual way, the junction between the courses being plainly marked These courses were from 2½ to 3 ft thick. Selecting these junctions as the weakest point of attack, the blaster drilled holes into the column 18 to 20 in. deep and 1½ in. in diameter From three to five holes, usually one on all four sides of the column, were drilled

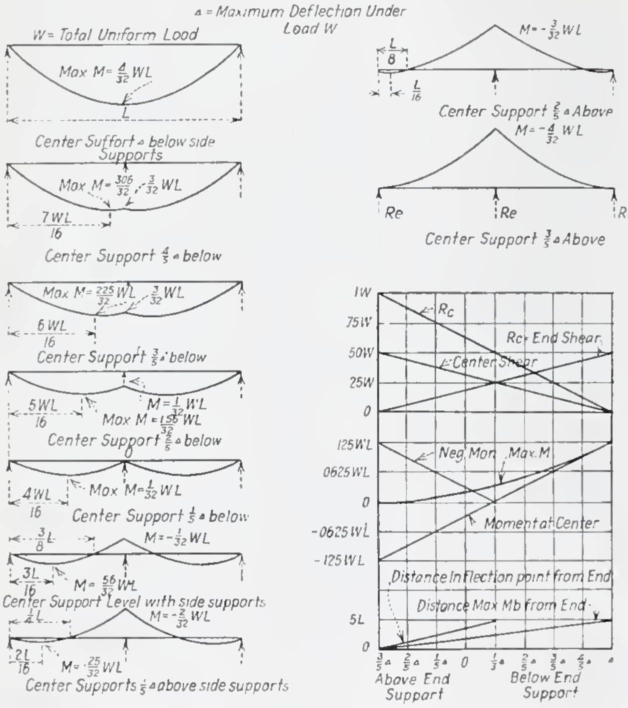
For the upper courses, ¼ lb. of 20 per cent dynamite was loaded in each hole and well tamped in with moist clay For the sake of safety, only one or two holes were fired at a time Had it not been for the danger of breaking machinery, windows, or the floor above the pier, better results could have been obtained by firing all of the holes together Where more than one hole was set off at the same time, it was necessary to use electric blasting caps connected up with a blasting machine circuit, because in no other way is it possible to make charges go off at exactly the same instant, and unless they do go off that way the result is not satisfactory. After loading the holes, blasting mats were made of burlap bags bound together to a thickness of about 4 in. and thoroughly saturated with water. These mats were hung over the bore holes to prevent any flying chunks of cement damaging surrounding objects. In all, about 10 lb. of dynamite were required to break up the pier. The dynamite cost $2.50 and the blasting caps about $1.25. Labor cost amounted to considerably less than a day's time.

Dangers in Shoring Beams

By WALTER W. CLIFFORD.

Indiscriminate shoring of beams may be harmful rather than helpful. A center shore will not increase stresses beyond the previous maximum but it may cause equally large stresses in a different part of the beam. With a beam of constant cross-section like the ordinary steel or wood beam this will do no harm but may do no good. In the case of a concrete beam or truss or a built up steel girder a center shore may increase stresses in portions of the member not designed or able to take them.

The following curves indicate the variation of stress in a uniformly loaded beam with a center shore at various heights relative to the original supports. For convenience of computation $\triangle$, the maximum deflection of the unshored beam is taken as a unit of height. The curves show the moments for elevations of center support $\triangle$, $\frac{4\triangle}{5}$, $\frac{3\triangle}{5}$, $\frac{2\triangle}{5}$, and $\frac{\triangle}{5}$ below the end supports, at the same level, and at $\frac{\triangle}{5}$, $\frac{2\triangle}{5}$ and $\frac{3\triangle}{5}$, above the end supports. In the first case the end supports take the entire load, in the last case the center support takes the entire load. Following these moment curves the variations of shear and reaction as well as moment are plotted.



Examinations for Structural Engineers.—The U. S. Civil Service Commission will hold open competitive examinations for senior structural engineer, Grade 1, at $3,000 to $4,000 per year; senior structural engineer, Grade 2, at $1,800 to $2,700, and senior mechanical engineer, Grade 2, at $1,800 to $2,700. Vacancies in the Interstate Commerce Commission under the act providing for the valuation of the property of common carriers, at the salaries indicated, and in positions requiring similar qualifications, at these or higher or lower salaries, will be filled from these examinations, unless it is found in the interest of the service to fill any vacancy by reinstatement, transfer, or promotion. For the first mentioned position it is desired to secure eligibles having (a) a thorough technical training and practical experience in connection with the design, construction, or maintenance of railway structures (bridges, docks, wharves, buildings, etc.), and (b) having a thorough acquaintance with the methods of inventorying and cost estimating of railway property acquired in the service of carriers or of Federal or state commissions. Applications must be filed with the commission at Washington, D. C., by Nov. 11.

Importance to the Contractor of Preventing Minor Accidents

In a paper presented early this month at the eighth annual safety congress of the National Safety Council, Mr. Geo. A. Rutherford, a building contractor of Cleveland, O., called attention to the broadening scope of most state compensation laws, as manifested in greater liability toward the injured person. Formerly compensation was rarely paid, for instance, for the impairment of one eye, because it is seldom possible to prove direct lessening of earning ability by the impaired vision of one eye. However, at the last session of the Ohio legislature the law was amended to grant compensation under this condition. Still further argument for using every precaution to avoid even seemingly trivial accidents is found in the extension of the merit-rating system by the Industrial Commission of Ohio so as to provide for a return in the form of a credit premium of $10 of every $100 a subscriber may save the state fund below the ratio of the basic compensation allowance and credit premium factor prescribed for his operations. This has the effect of establishing a preferred plus rating for every industrial risk who is able to produce a preferred plus experience. This new plan becomes operative against expirations occurring on and after Jan. 1, 1920, and will apply retroactively for the preceding six months' insurance period. Thus a more direct financial incentive than theretofore is brought into play as an inducement for employers to co-operate with the fund.

Mr. Rutherford recommended the following as prevention measures on building work:

First: A closer contact by contractors with their men, with a view to personal education in safety rules. Impress upon superintendents and foremen their responsibility for the safety of those who labor for them, the necessity of warning them of danger and also to impress upon them the necessity of scrupulous care in handling appliances and tools.

Second: A periodical inspection by the contractor or his superintendent of daily used appliances, such as ladders, ropes, tackle, hoists, mixers and other machinery.

Third: The insistence upon keeping all jobs free from débris, which is one of the greatest causes of small accidents.

Fourth: Making it compulsory that all openings in floors be immediately provided with railings; that all staging, especially where bricklayers and masons are working, should be provided with toe boards or screens to prevent falling of brick and other material.

Fifth: The display of "Safety First" signs on every building, printed in foreign languages as well as English. These signs, in addition to being a constant reminder to workmen, would also serve a like purpose to the employer.

Sixth: The distribution, at frequent intervals, of circulars or small cards to be inserted in workmen's pay envelopes. Various brief exhortations may thus be taken without offense To use every effort, not only to avoid accidents themselves, but to assist others in doing so. This latter may be done by the prompt reporting of any defect in or about a building that may lead to an accident. How often do men continue to be in danger after they fear something may happen until it actually does happen, and then declare, "I was afraid of that all the time," or "I told you so."'

It probably is not possible for those in the building trades to deal with the subject as well as employers having all their employes under one roof with first aid and welfare department well established, and it obviously is not possible for the average contractor to employ a safety engineer, but in all cities of any size there are associations of employers in the building trades and it would be practicable and possible for these groups of employers to provide a safety department in charge of an expert safety engineer who would be a member of the National Safety Council, and whose duty it would be to gather and disseminate information on safety matters among members of the association, to provide for periodical inspection of jobs, including machinery and equipment, to make reports and recommendations directly to the members to provide posters, safety signs, etc., in fact, to do for the group of contractors what the safety engineer of a large contracting company does for his corporation.

Significance of Cracks in Reinforced Concrete Construction*

The cracks that occur in reinforced concrete can in general be classed under five heads:

(1) Cracking due to contraction of concrete in setting; (2) cracking due to expansion and coutraction caused by temperature changes in the concrete; (3) cracking due to too early removal of forms; (4) cracking due to overloading of the structure; (5) cracking due to settlement of supports.

Shrinkage of concrete in setting varies from 0.15 per cent to 0.2 per cent of the length for neat cement, and from 0.03 per cent to 0.05 per cent for concrete poor in cement. The poorer in cement a given concrete may be, the less shrinkage there will be. The increase in tensile strength obtained by the addition of extra cement is neutralized to some extent by the increased possibility of contraction cracks.

This is a point which should be berne in mind when designing structures to hold water or other liquids. In these structures all the tensile stresses should be taken by the steel, and it is of the greatest importance to have a concrete which is dense and not liable to contraction cracking. A 1:2:4 concrete, made of properly-graded materials, will be sufficiently strong and dense for most tank work, and is likely to develop less contraction cracks than a richer mix.

Cracking frequently occurs through expansion and contraction, due to temperature changes, especially in those parts of the structure which are exposed to the sun and weather, such as roofs and external walls.

A great deal of this cracking can be minimized by the adequate provision of temperature steel, but within limits a certain number of minor temperature cracks are inevitable, and should be recognized as inevitable. They are unsightly, perhaps, but as a rule do not affect the strength of the structure.

Removal of forms too soon produces cracks in floors and weak spots in walls. In the cases of floors, if the forms are removed too soon slight settlement occurs, and the soffits of beams and the slabs develop fine hair cracks. In the case of walls there may be no visible sign of any injury, but they often divide at places in their thickness, which may be ascertained by tapping them with a piece of wood or metal, when the hollow sound produced is evidence of the result. Cracking due to this cause should never occur if the job is properly supervised.

Overloading of the structure or considerable settlement of supports produces the most serious cracks; in fact, they are usually the only kind of cracks of any considerable moment occurring in concrete structures. Cracks due to this cause usually occur as fractures in columns or as diagonal fractures in main or secondary beams. If such cracks occur, steps should be taken to remove the load and to strengthen the members affected. Sudden failure is not likely to occur immediately on the appearance of such cracks, as beams and columns generally will carry a lot more load after the first appearance of cracks, before final failure takes place. The appearance of these cracks, however, is often an indication that the member is overstrained.

All masonry structures, including reinforced concrete will develop cracks. Structures of masonry, stone, or brick, are discontinuous and jointed. The cracks in them due to any cause are dissipated, spread over innumerable beds and joints of the construction. In a reinforced concrete structure built as a monolith, without beds or joints, the same reasons for cracks exist, but the cracks are very apt to concentrate themselves in well defined and ugly openings, especially so if the steel reinforcing is not sufficiently and properly disposed. The cracks in concrete, due to the same causes as those in ordinary masonry on account of their prominence are all out of proportion to their significance. Such cracks as a rule do not affect in the slightest degree the stability of the structure, and are no greater in their totality than the numerous smaller cracks to be found in the joints of any brick or stone structure.

In a properly designed and constructed reinforced concrete structure there should never be serious cracks in the main structural members, and any cracks in the slabs supported by them are generally quite trivial from the point of view of structural significance. Much worry would be saved by many architects and engineers if this were recognized and frankly accepted. It is useless to promise to erect a large concrete structure which shall be free from shrinkage and temperature cracks. Much can be done to minimize these cracks, but they cannot be entirely avoided.

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*From the proceedings of the Royal Victorian Institute of Architects.

Uniformity of Structural Features in Concrete Apartment Buildings

Mr. Henry J. Schlachs, a Chicago architect, makes the following observations on the design for Reinforced Concrete Apartment Buildings in the October-November number of Concrete in Architecture and Engineering. "In most cases there is the possibility of simple repetition of the unit—the same plan for each apartment—so that the structural divisions can be standardized. The same argument applies to hotel planning, which is practically the apartment hotel on simpler lines.

The architect and engineer should combine their efforts upon completion of the preliminary sketches. In hardly any case do the plans require anything which may not be harmonized to structural simplification. Only for elevator and stair framing need the standard of panels be varied. Columns should be the same size from basement to attic, and while it is true that this takes more concrete, the resulting saving in labor more than offsets the cost of the extra concrete. Imagine, for example, in addition to the saving in changes in form sizes for girders, columns and other members, the saving of endless calculations to maintain room sizes, pipe risers, and other necessary features, all of which are obviated when the fixed structural points are constant. Three forms of floor are in general use: Flat slab, tile in concrete joist, and open form. The last is no doubt winning preference as it develops opportunity for ingenious form centering, tending to make it of lower cost by comparison with other types. The open form reduces weight and hence price, other things being equal. Probably the day is not far distant when we will have the fabricated column, in sections 2 or 3 ft. high, delivered at the building, thus simplifying form construction and presenting considerable saving of time and form supports, because such columns would be able at once to take the load and save the time which form supports must now be left in place.

As the apartment hotel type of building becomes more and more a factor in the building world, there is certain to develop co-operation among the producers who specialize in it. Certain established standards of sizes are bound to prevail—for example, one size of windows except for bath-rooms, a standard size for doors, all of which will make for much less confusion in the innumerable accessories related to such features. In the case of windows, imagine the effect of one size instead of five on the location of perhaps 1,000 which must be provided, each involving glass, sills, weights, frame, sash, trim, shades, screens, awnings, etc. The same is true of structural members and goes to show that one common size for common members will effect considerable saving of time, labor, and material, as well as reduce confusion in construction details in many parts of the building.

My motto with reference to the structural design of this type of building is to change everything, if you will, but the uniformity of columns, girders, and panel sizes. For girders maintain a standard width and depth and make the changes in the amount of steel. Only after much experience can one realize the saving thus effected. For girder depths regulate the height of partitions and change in grounds.

This is an architect's observation of concrete construction as applied to this type of building and while it seems to treat rather of the architectural elements of such a building, my purpose is to bring out the indisputable fact that the entire concrete problem is an engineering one, that the engineer must design and assume responsibility for the integrity of the structural design, and as the above is a fact, the plan of the building must be an outgrowth of the requirements of the engineering design, based upon the merging of modern building architecture and engineering.

Paraffin Method of Making Silo Walls Air Tight

Silos made of concrete, brick, or other material of porous or semiporous nature are benefited by an inside coating of a preparation which seals the pores and also prevents the action of silage juices on the walls. The coating most commonly used hitherto is coal tar thinned, with gasoline and applied with a paint brush. A number of materials of like nature have been considered for this work, but the one showing the most promise is paraffin, states the Reclamation Record.

Paraffin may be applied either cold or hot to silo walls. With the cold method the paraffin is dissolved in a volatile carrier like naphtha until a saturated solution is obtained. Four pounds of paraffin dissolved in ½ gal. of gasoline or naphtha will make 1 gal. of this solution. The solution is then applied much like paint to the surface of the concrete, which it penetrates according to dryness and porosity. One gallon has a covering capacity of about 200 sq. ft.

The naphtha soon evaporates, leaving the paraffin in the holes. When applying the paraffin by this method, special care must be taken that there is good ventilation in the silo and that there are no lights or fires near by. Naphtha is very inflammable, and a serious explosion or fire may result from careless use.

Paraffin may also be applied in melted form. It requires 6½ lb. of paraffin to make 1 gal. of the hot paraffin solution. The work should be done on a warm day, and the concrete must also be sufficiently warmed by artificial heat so that the paraffin may be thoroughly rubbed in. One gallon will cover about 250 sq. ft. of surface. When this method is followed a blowtorch should be used to warm the walls as the paraffin is being applied and also to thin and spread the layer of paraffin. Two buckets of paraffin should be used, one to be heating while the other is being applied. The hot-paraffin treatment is one of the most successful for waterproofing surfaces exposed to weather, but it requires some experience to obtain successful results.

To Organize Federal Department of A. A. E.—As an outgrowth of the resolution adopted at the last convention of the American Association of Engineers that a committee should be appointed to promote the non-technical interests of engineers in public service, the board of directors of the American Association of Engineers recently authorized the organization of a Federal Department of A. A. E. This department will be composed of all engineers who are employed by the Federal Government, and will have its headquarters in Washington. The engineers in the different departments and bureaus of the Government will organize into sections which will be a part of the Federal Department. Sections will be organized into local branches. There will be, for instance, the San Francisco Branch of the Navy Section of the Federal Department of the American Association of Engineers. Branches and sections will be subordinate to chapters having jurisdiction over the territories in which they are located. The Federal Department will be financed in the same manner as the railroad campaign was financed at the beginning; the engineers to be benefited by the department will be asked to subscribe from $1 to $5 each to an organization fund, which will provide for the initial outlay and the expansion of the district office in Washington.

Drainage Engineers Wanted.—The U. S. Civil Service Commission will hold an open competitive examination for drainage engineer to fil positions in the U. S. Bureau of Good Roads, Department of Agriculture, at $1,800 to $2,100 a year, and in positions requiring similar qualifications. Competitors will not be required to report for examination but will be rated upon education and preliminary training, experience in engineering and fitness and experience in agricultural drainage engineering. Applications must be filed with the civil service commission at Washington, D. C., not later than Nov. 4, 1919.

Pneumatic Mixing of Paint.—Compressed air is used at the Harlem repair yard of the Terminal Railroad Association of St. Louis, in mixing paint. The paints are prepared in barrels, each barrel having a stirring rod, 5 ft. in length, made of ¾-in. pipe and fittings. The handle of the rod consists of tee with a pair of short nipples and caps. A second tee, a foot below the handle, forms the point of attachment for the air hose connecting with a pressure line. A globe valve in each lead to the paint barrels, permits adjusting the flow of air through and out of the lower ends of the stirrers in such volumes as may be needed.

Personals

Gerald R. Yearsley has been appointed chief factory inspector by the Industrial Commission of Utah.

Sherman W. Belding and Oscar F. Bellows, engineers of the State Department of Public Works of New York, have been transferred to the state engineer's office.

Wirt J. Wills has resigned as general superintendent of the Memphis Artesian Water Department of Memphis, Tenn. His resignation takes effect Nov. 1. Mr. Wills has been connected with the department for 13½ years as chairman and general superintendent. He will now devote his entire time to the manufacture of the Wills pumping system, of which he is the patentee.

Capt. P. H. Brigham, 130th Engineers, U. S. A., recently returned from France after 19 months' foreign service, has received his discharge from the army and has entered the service of the paving department of the Lakewood Engineering Co., Cleveland, as field engineer for New York, New Jersey and New England. Before Capt. Brigham entered the army in May, 1917, he was employed as assistant engineer with the New York State Highway Department with headquarters at Binghamton, N. Y.

Julius Adler has resigned as engineer of tests of the Pennsylvania State Highway Department to accept the position of technical engineer in the asphalt department of The Atlantic Refining Co. Mr. Adler was assistant engineer in the Philadelphia Bureau of Highways from 1912 to 1916 and engineer of tests of the Pennsylvania State Highway Department from 1916 to 1919. He was with the U. S. Office of Public Roads in 1908-1909 and the City of Seattle in 1910. Between 1908 and 1912 he was also instructor in civil engineering at the University of Pennsylvania and instructor in charge of highway engineering work at the State University of Washington in Seattle.

Harry Barker and Robert C. Wheeler announce their association for the practice of engineering and the establishment of an office at 1512 Maiden Lane Bldg., 170 Broadway, New York City. Special attention will be given to public utility engineering, including valuations, rates, operation and management; to hydraulics; to power development and utilization; water supply and purification; sewerage and sewage disposal; municipal problems, including city transportation and civic improvements; development of new processes, and reports for investors. Mr. Barker is a graduate engineer (University of Vermont), with over 15 years' broad experience in electrical, mechanical and civil fields. His earlier work included design and testing of power plants, and field laboratory work in hydraulics. For several years he was an editor of Engineering News and Engineering News-Record. Mr. Wheeler is a graduate engineer (University of Vermont), who has specialized for ten years in the design, construction and operation of water supply and purification plants, sewers and sewage disposal works. His earlier work was in railroad construction. For over 5 years he was associated with George W. Fuller. Mr. Barker was recently released from military service as captain of engineers. Major Wheeler at present is chief of the water supply section of the Construction Division of the Army.

Obituaries

William E. Alexander, superintendent of bridges and buildings of the Bangor & Aroostook R. R., died Oct. 9 as the result of injuries received in an accident.

Noble Maxwell, formerly president of the Rowe Bros. Co., dredging contractors, died Oct. 12 at his home at Portland, Me. His company built the Standard Oil docks in Portland, Me., the Plymouth Beach breakwater at Plymouth, and the draw span in the Portsmouth-Kittery bridge.

Joseph W. Holmes, inventor and engineer, died Oct. 15 at Batavia, N. Y., aged 88 years. He invented the solar theodolite and other surveying instruments. Mr. Holmes served many years as municipal engineer for Batavia. He also was engineer for several companies formed during the past three decades.

Brig.-Gen. William T. Rossell, U. S. Corps of Engineers, died Oct. 13 at his home in New Brighton, N. Y., aged 70 years. He was graduated from West Point in 1869 and commissioned in the engineers, rising to the rank of brigadier-general in 1913, shortly before his retirement. During the war he served on the rivers and harbors board, of which he had been president from 1906 to 1913.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Steam Specialties.—McAlear Mfg. Co., Chicago, Ill. Catalog covering steam, water and air specialties for high and low pressure heating and power plants and devices for plumbing installations. Also catalog covering vacuum, vapor and air line heating specialties.

Industrial Lighting.—National Lamp Works, General Electric Co., Nela Park, Cleveland, O. 96-page bulletin of the Engineering Department. The discussion covers: The requirements which must be fulfilled in the design of a satisfactory installation; information on Mazda lamps; a discussion of reflecting and diffusing equipment; A discussion of the lighting of yards and boundaries; information and cost data necessary for the solution of industrial lighting problems. The same company also has issued a 36-page booklet entitled "How to Plan the Lighting Installation for a Factory."

Industrial Notes

G. E. Anderson, formerly assistant to the vice-president of the American Locomotive Co., has been appointed assistant eastern sales manager of the Duff Manufacturing Co., with headquarters at its eastern sales office, 50 Church street, New York City.

The Ingersoll-Rand Co., New York City, has established a branch office in the Sam Houston Life Bldg., Dallas, Tex. The office will be in charge of R. H. Brown, Jr., as manager. Mr. Brown has heretofore been connected with the company's St. Louis office and has for years been in intimate touch with the Texas-Oklahoma territory.

Foreign Engineering Review Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field if subscribed for as a weekly at $3.00 a year; but any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year (or any two monthly issues at $1.50 a year) and the 4 special quarterly issues will be sent without extra charge. Three of these special quarterly issues relate entirely to foreign engineering and construction practice, and the fourth is our annual "New Equipment Issue." The *articles* in the first two issues of each month (1st and 2nd Wednesdays) completely cover the municipal engineering and contracting field. The *articles* in the first and last issues of each month (1st and 4th Wednesdays) completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and last issues of each month (3rd and 4th Wednesdays) completely cover steam and electric railway location, design and construction. See the "mast head" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
- (a) Roads
- (b) Streets
- (c) Street Cleaning
- (d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
- (a) Waterworks
- (b) Sewers and Sanitation
- (c) Irrigation and Drainage
- (d) Power and Pumping
- (e) Management and Office System

Railways and Excavation—3rd Wednesday
- (a) Excavation and Dredging
- (b) Rivers and Canals
- (c) Quarries and Pits
- (d) Railways, Steam and Electric
- (e) Management and Office System

Buildings and Structures—4th Wednesday
- (a) Buildings
- (b) Bridges
- (c) Harbor Structures
- (d) Miscellaneous Structures
- (e) Properties of Materials

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Why Do Most Practicing Engineers Study So Little?

In New York City and immediate vicinity there are more than 14,000 engineers of all classes. About 4,000 of these belong to the five national engineering societies. The consolidated engineering library is open not only to the 4,000 but to the 14,000 engineers in that city.

Of these 14,000 what percentage daily make use of the great library? Before making your guess, consider the following facts bearing upon the matter.

Engineering is one of the learned professions. Its literature is already vast, and is accumulating in geometrical progression. This holds true not only of engineering as a whole but of every branch, and of every twig of every branch of the profession. Hence a college course in engineering can give but a mere smattering of engineering knowledge even to the most studious students. Every professor of engineering is careful to tell his students that "commencement day" marks the beginning of a far longer course of study than he has just finished.

Bearing these facts in mind, ask yourself what would be a fair percentage of daily attendance at that great repository of engineering knowledge, the engineers' library in New York City. Then make your guess as to the average percentage of daily attendance.

Would you be surprised to hear that only one engineer in ten uses the library daily? No? Would you be surprised if the number were only one in fifty? No? Would you be surprised were it only one in a hundred? Well, as a matter of fact it is but a trifle more than one in two hundred, for the average daily attendance is only seventy-eight!

Turn this fact over in your mind, and then ask yourself its signficance. Does it not indicate a pretty sorry failure on the part of teachers to inculcate habits of studiousness? Isn't that the outstanding inference from this fact? We are not speaking now of engineering teachers only, but of teachers in high schools and lower grades. All teachers admit that one of their prime objects is to train their students to become studious, and consequently to remain studious after their days of schooling are ended. If this is one of the aims of educators, do not such results as those above cited prove that the aim has pretty nearly failed of accomplishment?

It will naturally be said that the facts above cited are not conclusive evidence, and this we readily grant. But these are not the sole facts in our possession. Of the same sort are such facts as the following: (1) The relatively small circulation of all engineering periodicals combined, compared with the total number of men who would benefit by reading them. (2) The relatively small sale of even the "best sellers" in the technical book field to say noth-

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

ing of the low average sale of the best book in each specialty. (3) The relatively small membership in all engineering societies. (4) The insignificant attendance at the technical meetings of those societies. (5) The ridiculously meager technical library of the average technical man, even as relates to his own specialty. (6) The candid admission of the average practicing engineer that he pursues no systematic course of study or research. (7) The meager daily attendance at local engineering libraries. (8) The general persistence in using inferior designs and construction methods for years and years after superior designs and methods have been published repeatedly.

As an editor the writer finds it necessary to read a great part of the current literature in the civil engineering field, to visit engineering works throughout America, and to interview civil engineers of all grades and ages. As a publisher of engineering books and magazines the writer is necessarily familiar with technical book sales and subscription statistics, not only as relates to his own business but in competitive fields. The writer, therefore, is not imagining facts to prove his contention when he cities the eight facts above given. Moreover, the conclusion that he has finally arrived at is one that he has been very slow, even loath, to come to, for it is certainly not a conclusion that is flattering to engineers in general, and therefore not a statement that will be received with satisfaction by many engineers. Still less will it please most teachers of engineering to be told bluntly that, on the average, they are failing, and failing badly, in one of their main aims, namely, to train men to be systematically studious in after life. But, having come to the conclusion that this is a fact, it would be inexcusable cowardice not to state our conclusion.

At first sight it seems incredible that the average person can spend eight to sixteen years in school without becoming so habituated to studying as to remain thereafter a student. It requires no little knowledge of psychology and logic to explain this paradox. In his "Talks to Teachers on Psychology," Prof. William James pointed out that a child is a little more than a "walking bundle of habits," the habits being those inherited plus those personally acquired. He might well have added that what is true of the child, in this respect, is true also of the average adult. If so, the average man will be found doing little more than he has been habituated to do. He may do less, because it is often easy to drop an acquired habit, particularly when it is resisted by strongly inherited habit or instinct; but rarely does the average man undertake, of his own volition, a new line of thought or action. This is partly summed up in the old adage, "You can't teach an old dog new tricks," to which should be added for completeness sake, "and no old dog ever teaches himself a new trick." The question then is: When does the "dog" become old? Prof. James answers by saying that few men change their habits of thought and action to any marked extent after they are about 25 years old. There are exceptions, but they are rare. So much for the psychology of our problem; now for the logic of it.

The word "study" is rarely defined, but even a cursory examination of its significance discloses several kinds of study. The boy who memorizes a lesson in history is "studying his lesson." So, too, is the boy who is searching for additional historical data not given in his text book. So, too, is the boy who is attempting to draw his own general conclusions from the historical facts that he has found. Here are three distinct types of mental action, all classified under the head of "study," namely: (1) Memorizing, (2) search, and (3) inductive inference. Yet these three are not all the subclasses of study. There are two other subclasses: (4) Invention and (5) deductive inference. Moreover, this fifth class is divisible into two subclasses, namely (a) quantitative or mathematical deduction and (b) qualitative or ordinary deduction.

To anyone familiar with elementary psychology it will be apparent that a student may become habituated to any one of these six classes of study, yet not become habituated to the remaining five. An engineer, for example, may be well trained in mathematical deduction but very poorly trained in searching for data. Now it is precisely this sort of distinction between the different classes of studying that explains why a student may spend 8 to 16 years in school and fail to remain a student in after life. Let him, for example, become quite proficient in memorizing and in using mathematical data, but not very proficient in other lines of study. Let him secure a position as inspector on construction work requiring little or no memorizing or use of mathematical data, and he will not be inclined to study the literature relating to what he is engaged in doing. He is quite apt even to stop studying, mathematically, but he is almost certain to do little or no searching for qualitative information.

It will be claimed, of course, that the average engineering student is not so one-sided in his training as this hypothetical student, and that we grant at once. All that we aim to establish is that he is sufficiently one-sided to make him a relatively poor student of the sort of facts that he should use in the practice of his profession. Almost without any training in searching for information, the average American engineering student begins his professional career without the needed habit of searching for data. To put it in the vernacular, he is a "rotten" student of what other engineers have done and are doing.

It is entirely beside the point to argue that the habit of searching for data should be self-acquired, for our contention is that relatively few people ever do acquire any habit of their own volition. Habits are, for the most part, either inherited or imposed upon us by external authority. Failure to see the significance of this psychological fact, coupled with failure to differentiate between the different kinds of mental activity embraced under the general head of "study," seem to account for most of the defectiveness in existing methods of teaching. A teacher should be regarded as a mental "coach," a trainer of mental athletes, and not as a mere expounder of facts and methods. Going further in the analogy, let it be noted that the trainer of athletes realizes that the legs are not made strong by exercising the arms. For similar reasons exercise in mathematical deduction does not strengthen the "faculty" that controls the "thirst for information."

College professors frequently urge students to read current technical literature, and many go so far as to advise the students to subscribe for technical periodicals. This, while helpful, is not enough to establish the habit of searching for facts. Furthermore, it fails to provide a definite goal and a systematic method of reaching it. Students, from the freshman year onward, should be given problems involving a thorough search of engineering literature. This is rarely done. How rarely it is done may be judged by such facts as the following:

There are 106 American colleges that have a course in civil engineering. Only 36 of these colleges subscribe for Engineering and Contracting; yet there are only two American weekly periodicals of national circulation covering the entire civil engineering field with their articles, and this journal is one of the two. Moreover, this journal has been a national weekly magazine for nearly 14 years, and every engineering college library and every head of the civil engineering staff of teachers has repeatedly received sample copies of this journal. Is the failure of two-thirds of these colleges to subscribe for this journal ascribable to the ephemeral character or uselessness of its articles? If so, ten thousand subscribers have been deceived into subscribing, and many of them have been thus deceived for years. If so, the 36 colleges that do subscribe are deceived. If so, Professor Arthur H. Blanchard and his 17 co-authors of the recently published "American Highway Engineers' Handbook" (1,800 pages) have been deceived, for in that book there are the following numbers of references to road and street articles that have appeared during the past ten years:

Engineering and Contracting	212
Engineering News	99
Engineering Record	88
Engineering News-Record	12
Good Roads	71
Municipal Engineering	69
Municipal and County Engineering	40
American City	31
Total	622

There were a few other scattering references to articles, but the above tabulation shows the leading journals in point of number of articles referred to in the bibliography in this book.

Recently one of our representatives visited an engineering college and asked permission of the head of the civil engineering department to solicit subscriptions from the students. This request was denied. Then he asked the professor whether he would not himself advise the students that Engineering and Contracting is a good civil engineering periodical to read. This request also was denied. Pressed for a reason for the last refusal, the professor said that he could not conscientiously recommend Engineering and Contracting because he had never read it! Then, evidently feeling the weakness of such a reply, he asked that Engineering and Contracting be sent to him for a year, so that he might form an opinion of it. Now, obviously such a request as this would be granted at once, and gladly granted, but why had the request never come from this professor until he was importuned to explain his lack of knowledge of the character of the articles in this journal? Moreover, why should he ask for a year's time in which to come to a decision as to its character? This is not the method that the average man uses in deciding an important question, so the inference is that to this professor the question as to what current literature his students should read is relatively unimportant!

While we have just cited an extreme case, is there really such a wide gap between the outspoken statement of this professor and the quiet ignoring of our repeated requests to 70 engineering colleges to subscribe for this journal? What, we ask, is the real significance of the fact that two-thirds of the engineering colleges in America do not subscribe for Engineering and Contracting? We put this question not only to our subscribers now, but we shall send copies of this editorial to 8,000 civil engineers who are not now subscribers, asking their inference from these facts.

When two-thirds of our engineering schools do not have in their library a file of one of the two American weekly periodicals covering the entire field of civil engineering, is this fact not conclusive evidence that most of the teachers of civil engineering do not habituate their students to exhaustive search for information? Is it not evidence that they do not undertake systematically to stimulate a burning thirst for useful knowledge, but leave to chance the development of such an appetite?

Finally, we ask: Among all the habits to which great professional and scientific men ascribe their success, is not the greatest credit ascribed to an insatiable thirst for useful knowledge? A "thirst," whether physical or mental, is evidence of an habitual action and an appeal for its exercise. But where do we see a general thirst for knowledge among any class of men taken as a whole? Must we despair of creating such a thirst? If we do, we must coincidently despair of improving our educational systems to any marked extent, for the grand object of formal education is to make self-education after graduation an inescapable habit.

Concrete Pavement Construction in Liverpool, England.—In a discussion of a paper presented last July at the annual meeting of the Institution of Municipal and County Engineers, Mr. J. A. Brodie, Municipal Engineer of Liverpool, stated that all the streets in his city had a foundation of at least 6 in. of concrete and in many cases 10 in. or more, according to the class of traffic. He stated that just before the war he decided he could put down concrete pavement as cheaply as ordinary macadam by utilizing destructor clinker, which cost next to nothing, as the aggregate. In some cases they put into the top surface of the concrete a 6-in. coating of ordinary macadam, taking care that each of these stones was properly fastened in the surface of the concrete. They then put a thin coating—not more than ⅜ in. or less—of a pitch mixture. Even under considerable traffic these surfaces had given excellent results. In other cases they put down 1½ in., and even as much as 3-in. of pitch macadam on the surface of the concrete, and in every one of these cases the result had been highly satisfactory.

Daily Per Capita Water Consumption of 10 Gal.—In a paper presented last September at the 45th Annual Congress of the Incorporated Sanitary Association of Scotland Mr. Robert Lindsay of Midlothian gave some statistics regarding the daily supply of water used by a small area in his county where there were 27 houses. The figures, he said, had been checked by meter so that they could be accepted as accurate. During the 728 days ending Sept. 2, 1919, 1,124,000 gal. of water were supplied. That meant a daily consumption of 1,543 gal. for 27 houses, or 57.15 gal. per house. As there was an average of 5.7 persons per house, the daily consumption per head was 10 gal.

James Watt and His Immortal "Patent"

Editorial in The Engineer (London), Aug. [illegible]

On Aug. 25, 100 years ago, James Watt died, leaving a name which will live in the annals of engineering till engineering is no more. It has been said of him by Draper, the Buckle of America, that he "conferred on his native country more solid benefits than all the treaties she ever made or all the battles she ever won." Experience serves but to confirm that dictum. The acts of monarchies, empires, and republics wane and vanish; the politics belauded today are derided tomorrow; statutes grow mildewed and forgotten; the most solemn treaties are torn up like scraps of paper, but the great basis and foundation of the welfare of nations, the source of motive power, remains, not unchanged indeed, but ever moving forward from good to better. The rise and progress of Britain's industrial greatness are founded upon Watt's engine. From the day when the Newcomen model fell into his hands we date that wonderful period of prosperity when Great Britain was the workshop of the world. Years had to pass before the first Watt engine pumped water, and more years before the rotary type opened a new era in factories; but the seed was sown in 1764, when the young instrument maker to Glasgow University set the Newcomen model to work and began that inquiry into its surprising consumption of steam which came to fruition suddenly in the year following with the conception of the separate condenser. They were years of trial and perplexity. Watt was a thousand pounds in debt and with no assets but his brains, when in 1769, at the age of 33, his immortal patent was granted. Three years and more passed in which the fate of the engine hung in the balance. Watt, to support himself and his household, took to civil engineering for a livelihood, but at length he found in Matthew Boulton, of Birmingham, the coadjutor who was needed to crown his efforts. In '75 he joined Boulton at the Soho Works, and in the same year secured a long extension of his patent, and in the following year the success of the invention was proved beyond all question when the first engine built to a commercial order, that for John Wilkinson, of Broseley, was set to work.

With the great inventor's work all mechanical engineers are familiar, for they see every day expansive working, the reciprocating piston, the centrifugal governor, the indicator, and the revolution counter. Just as Stephenson left a type of locomotive which has remained essentially the same for 90 years, so James Watt left a fixed engine which time has failed to alter in its fundamental characteristics. One may suspect that it is so with all great inventions, for they are in their essence simple and elemental. They suffer changes, but they do not disappear as lesser inventions do. The reciprocating engine is challenged by the turbine, but it still holds its own and it may be doubted if in another hundred years it will not continue to develop an appreciable portion of the power the world needs. But it is not of Watt's works so much as his mentality that we desire to speak today. There is no man who does not feel that, as this crisis in the industrial history of Great Britain, a new Watt is needed, and could we but fathom the secret of his greatness then might we find another such as he, one who by revolutionizing his work as he revolutionized that of Savery and Newcomen and Smeaton, might launch this country on a new wave of manufacturing pre-emience. It has been claimed for Watt that he was the first man who attacked the problem of the steam engine on scientific principles. His predecessors, even the greatest of them, Smeaton, were content to use what they found to their hand or to improve it by empirical methods, the methods of step by step mechanical enlargement or amelioration. Watt, on the other hand, when he found that the Newcomen model was consuming many more cylinders-full of steam than were accounted for by the number of strokes, was not content to say "it must be so, let us make the best of it"; he set himself to inquire why it was. Then, having without much difficulty reached an answer, which one imagines must have been familiar, in part at least, to all engineers of the day—in later years he himself said it was at once obvious—he began to devise means for improving the economy. At this stage we find him exercising a talent which stood him in good stead all through his life, a talent which he had acquired in the years of his delicate youth, the talent for meditation or reflection. He had the art of putting a problem into his mind and of leaving it there to develop. He tells us himself that his great idea, the idea of the separate condenser, came to him on a Sunday walk on the Green at Glasgow. The subject had been on his mind for months and came to fruition by sub-conscious action. We should like to insist on this curious fact. We are all well aware that thoughts come to us suddenly, that the solutions of problems spring into existence unexpectedly, not when they are being most earnestly sought, but when the mind is brooding. We can think of no word that expresses the condition more nearly than meditation. All great thoughts, whether they be inventive or philosophical, spring, we suggest, from meditation, from putting problems into the mind and keeping them there. As an art meditation is in bad odcr in engineering circles today. It is not encouraged; it looks too like idling The manager expects his inventors to sit down before their drawing boards and invent with pencil and pantograph, and as a consequence the bulk of inventions are empirical improvements on what has preceded—very useful work indeed, but never reaching to the height of the great fundamental inventions. It would possibly serve us well if we engaged professional meitators, men who were not expected to produce anything, but would saunter about the works or the library or the world at large and "meditate" on specified problems. If once in a generation one such man invented the equivalent of the separate condenser the expense of maintaining all the others would be repaid a hundred-fold. But meditation without preparation is useless. The mind must first be saturated with basic principles or the sub-conscious activity has nothing to work on.

And here we come to a very important matter. Among the means of commemorating James Watt which are being advanced by that active committee in Birmingham, which has arranged the program for the 16th and following days of next month, may be found a proposal, fathered, we believe, by Professor Burstall, that a James Watt Chair of Engineering should be established at Birmingham University for the promotion of research into the fundamental principles underlying the production of power and the study of the conservation of the natural sources of energy. We have had the advantage of discussing this matter with Professor Burstall and of hearing an exposition of his plan at a luncheon held in Birmingham on Monday last, the centenary of Watt's death, and we understand that he is far less concerned about a college of bricks and mortar and laboratories and apparatus than about what we may call a college of intellect. Neither does he propose that utilitarian objects should inspire research, but rather that an inquiry should be made into the basic principles of motive power, principles which may or may not, as the gods direct, hereafter be turned to useful ends. This is a conception of research which has always appealed to philosophic minds, but which is incomprehensible to the average manufacturer or to the man in the street. We fear that it must be said with little or no hesitation that the manufacturers of Great Britain—and indeed more or less of the whole world—are without imagination. But even if the leaders of industry themselves could see that a study of basic principles would lead in the future as it has led in the past to industrial developments, they would have the greatest difficulty in inspiring their shareholders with the same sentiments. For this reason it is improbable that enough money would be forthcoming from manufacturing circles to establish great research laboratories; but, on the other hand, there are, thank Heaven, enough engineers in the British Empire—for we hold that this is the matter for the Empire and not for the kingdom alone—who should be willing to find the moderate amount that is needed to found such a chair as Professor Burstall has in mind, and there is no way in which they can help to commemorate the great man on whose work the prosperity of the Empire is founded than by subscribing to the expense of the establishment of a chair erected for the perpetuation of his name and for the continuance of an order of research which he began by his investigation into the basic principles of the lack of economy of the Newcomen engine. Here we should like to give a long quotation from Tredgold's introduction to his "Steam Engine," published in 1837, partly because it shows that 80 years ago men were thinking about research much as they are thinking today, and partly because it presents the matter with a terseness and precision which cannot be exceeded. Tredgold wrote: "It has been too common of late for mathematicians to complain of want of patronage, and to censure official authorities for not encouraging science, forgetting that research will always be estimated by its intermediate utility; and while they continue to confine their attention to abstract knowledge, while they do not devote a greater part of their time to its application to the wants and the welfare of society, they must be contented with a small share of those advantages which result from combining with practical skill the power afforded by abstract reasoning. They should recollect that Watt could have earned no fame, in any age or in any country where the value of mechanical power was unknown. In following the application of science to art I have not, however, I hope, been unsuccessful in adding also to the stores of pure science; and so far from being insensible to the value of abstract research, I wish it to be renewed with redoubled vigor by those who have spirit to break through the prejudices of existing systems, and study from Nature; but it should be cultivated with a desire to promote the great end of human research; that is, the improvement of the condition of man; otherwise the fantasies of the Greek philosophers might with equal force claim the student's regard. . . . Our imperfection consists generally in not being able to foresee all the circumstances which have an influence on the effects of causes; but in proportion as we proceed in knowledge we also acquire greater powers of perception; that which was at first difficult becomes easy, and the mind is often roused by the bright gleam of truth, breaking as it were accidentally upon a mass of obscure ideas, and rendering the true solution of the difficulty at once obvious."

It would be no more than tiresome to attempt to add anything to this clear exposition of the relationship between utilitarian and abstract research. Tredgold foresaw that abstract research was necessary, but at the same time he urged that it should be made into basic principles which might later be turned to the use and service of society. The truth is that neither abstract nor utilitarian research is greater or less than the other; both are needed and both should be carried forward simultaneously. The latter is best carried out under the control of the manufacturers themselves; the latter lies in the province of the universities and schools.

Geology of Concrete Aggregates

Editorial in Concrete and Constructional Engineering, London. July, 1919.

In placing before our readers a summary of Professor Boswell's recent paper on "The Geology of Sands and Aggregates," we hope to direct attention to, and arouse interest in, a group of methods of investigation which, in their application to the constituents of concrete, are comparatively new. In furtherance of this purpose we propose to supplement Professor Boswell's treatment of the subject by a general discussion of its scope and significance. At the outset we shall do well to consider what is meant by the "geology" of aggregates. Geology is by no means confined to the field study of rock-formations, although as such formations are the architectural units of the earth's crust, it is necessarily by their investigation that the geologist arrives at his most fundamental results, and builds up the details of the long and varied history which it is his object to elucidate. Concrete workers are not primarily interested in rocks as documents of geological history, but they are intimately concerned with the distribution and resources of the materials they employ, and this is a subject on which the geologist, by his special experience, is in a position to speak authoritatively.

But the scope of his work is much more detailed than this, for a necessary complement to field-work is the examination of representative rock specimens in the laboratory. Here the geologist has devised a series of methods of research which consist essentially of the application of physics and chemistry to the solution of the special problems which he desires to solve. Stated in the most general way, these problems involve the determination as accurately as possible of the present condition of any given rock, expressed in terms of mineral or chemical composition, structure, and texture, and the deduction by analogy or experiment of its mode of origin, and its liability under different circumstances to alteration or decay. All of these topics are of particular interest to the concrete worker, and the geologist, by the application of methods which he has made his own, should, therefore, be able to solve many of the problems associated with aggregates, and to guide the architect or engineer in the choice of the materials which, among those available, are most suitable for any given purpose.

Concrete is often a highly complex mixture, and the effects of weathering may be correspondingly complicated, particularly when the concrete is reinforced or otherwise associated with metals. Rain, as well as the moisture of the original mixture, promotes hydration, and may, with the aid of dissolved gases, salts, or acids, bring about changes that are sometimes advantageous, but more commonly deleterious to the structure. The gases of the atmosphere promote oxidation, and help effectively in the processes of solution, especially in large industrial centers where traces of corrosive fumes add their disintegrating force to the gentler agents of nature. The behavior and alteration of sulphides and the solutions formed from them and from sulphates require special investigation, more particularly from the point of view of their effects on steel-work, cement, and certain types of aggregates, and the relation of these effects to corrosion on the one hand, and the development of disruptive stresses through expansion, on the other. The geologist is well acquainted with the action of sea water on various types of rocks, and is therefore in a position to indicate its action, and that of salt water—where this is used in contact with floors—on the materials present in any given variety of concrete. In all these, and other similar problems, the geologist must bring to his aid a considerable fund of chemical ability.

On the physical side the problems that arise include those connected with changes due to temperature variation; changes which ordinarily proceed almost imperceptibly, but which in industrial operations involving heat, and most spectacularly in the case of conflagrations, may lead to localized structural damage, or to wholesale destruction. Other problems are those associated with surface-tension, which need to be considered in connection with the making and setting of concrete; and here the geologist is able to help by microscopic studies of structure, of the relation of surfaces to porosity and adhesion, and of the shapes and sizes of the particles of fine stuff present in the aggregates, whether due to crushing, inadequate washing, friability or alteration-products.

It will be clear from the preceding discussion that geological methods of research need not be confined to natural aggregates, such as sand, gravels, and crushed rocks, or to the raw materials from which artificial aggregates, such as slags, and bricks, are derived. Not only are the artificial aggregates natural in their ultimate origin, and "artificial" only in so far as they have been altered by the action of heat, but somewhat similar materials have been produced naturally by the action of heat generated within the earth on the raw materials, like coal, clays and shales, from which our coke-breeze, clinkers, burnt clays and bricks are derivatives. In the case of slags the resemblance to certain basic lavas is so marked that, although they have no field-geology, they can be described in the same terms as lavas, and their study has, in fact, been of great service to the geologist in his interpretation of many of the phenomena exhibited by lavas. Moreover, from the purely practical point of view, it is necessary to investigate artificial aggregates in precisely the same ways as those of immediately natural origin, and the results, whether embodied in descriptions, specifications or generalizations, cannot fail to serve as a basis for identification and comparison, and for the better comprehension of the qualities, good or bad, which control the behavior of different classes of aggregates under the various circumstances that may befall a concrete structure during its life history. It need not, therefore, be considered an unjustifiable extension of the field covered by the "geology" of aggregates to bring also the artificial aggregates within its boundaries.

In the above paragraph we have referred to the description and identification of aggregates, and to this part of the subject Professor Boswell devotes considerable attention, since it is necessarily the part on which every geologist can be of immediate assistance. The fundamental features of aggregates as materials are their mineral composition, their broader structures, and their more detailed—often microscopic—textures, and these can rarely be wholly determined without the examination of thin sections under the petrological microscope. The mineral composition points to the chemical suitability or otherwise of the material for its allotted purpose, while the structures and textures indicate the strength and toughness of the material, the way it will break, its homogeneity or variability, its grain size—a matter of great importance in many respects—its penetrability by cement or by solutions, and therefore its capacity for withstanding disintegration. Finally, in many cases, only an adequate examination or description on these lines can lead to an accurate identification of the material.

It is obvious that it is of litle use to gain information about the behavior of aggregates either by controlled experiments or special investigations, or from actual experience with concrete structures themselves, unless the materials concerned are accurately described and properly named. Otherwise the information cannot be applied to other materials of a similar nature, nor can it be used as a means of future guidance. The question of nomenclature is thus one of far more than academic importance. In particular it is strongly to be urged that specifications should describe and name materials with sufficient detail and discrimination to avoid the misconceptions that surround many of the commercial terms unfortunately in common use. Terms like ballast, granite, and trap-rock, unless qualified or otherwise made unequivocal, are often quite misleading. Ballast does not mean only "Thames ballast" (flint gravel) but it also includes gravels composed of quartzite, sandstone, limestone, granite, and other pebbles. One type of pebble may predominate, and the aggregate, especially if crushed, is then equivalent to one composed of crushed fragments of the rock-type represented. Many gravels, however, are of a composite nature, and are then equivalent to a correspondingly mixed aggregate. As a commercial term "granite" is applied not only to granite in its broadest geological sense, or to rocks like diorite and gneiss, but also to rocks as different from these as limestone, quartzite or schist (sedimentary and metamorphic), and dolerite, and other igneous rocks. It thus overlaps in meaning with "whinstone" another common term, which includes dolerites and basalts, and similar dark, fine-grained igneous rocks. The term "trap" is unfortunately so widely applied as to be of very little descriptive value. It includes not only the whinstones, and their altered analogues, the greenstones, but also a miscellaneous series of other types which may behave very differently as aggregates. Less than a score of names would, with suitable mineralogical and structural prefixes, be adequate to designate for most purposes the majority of the chief rocks used for concrete—provided always that they were properly applied. Surely it is desirable that those in charge of concrete work should know these terms and the chief properties which their application to a rock implies.

Professor Boswell directs attention to an important aspect of his subject in dealing with the shapes, sizes and grading of aggregates, an aspect which he explores more closely in his treatment of sands, on which he is a recognized authority. Unfortunately, space does not here permit any further discussion of the problems involved. On one point, however, we must take exception to a suggestion thrown out by Professor Boswell. He rightly considers that the gradation of sizes of the fragments of the aggregate and sand together should be as perfect as possible. But when he suggests that the aggregate should be screened down to particles as small as 1/50 in., and that sand of finer grades than this should then be added, he is proposing a quite impracticable method for arriving at a result which is ordinarily obtained with much greater ease. In practice, coarse aggregates are not generally screened down to less than ¼ or 3/16 in., and the smaller grades are added in the form of sand, which, in terms of Professor Boswell's notation, includes grades ranging from gravel, through very coarse, coarse, and medium sand to fine sand. The commercial significance of the term "sand" does not quite coincide with the meaning given to it by the geologist, but that need cause no confusion, since it is easy to speak of the "sand grade" or of the "coarse sand grade," etc. whenever it is necessary to specify or refer to particular limits of size.

Professor Boswell merits our gratitude for having discussed in a short space a wide variety of geological topic. In their relation to concrete. His concluding suggestion, that more detailed knowledge is required of the British resources of the materials employed, deserves especially to be emphasized. The task implied is one essentially for the geologist, and many of the results, when obtained, might advantageously be embodied in the Home Office List of Quarries, a publication which would be more generally serviceable if the rocks mentioned in connection with each quarry were described in geological as well as commercial terms.

Some Peculiarities of Algal Growths in Reservoirs

Editorial in The Engineer, London, Sept. 5, 1919.

In a previous issue we dealt with certain aspects of Sir A. C. Houston's thirteenth annual report on the results of the chemical and bacteriological examination of London waters. There were parts of it, however, which we had, perforce, to pass over with quite brief mention. Yet they are well worthy of more extended consideration. There have been many things in the past that have puzzled those in charge of slow sand filters. Sir Alexander's researches have done much to elucidate obscure points, but we feel sure that he would be the first to acknowledge that all has not yet been learned concerning the matter. It is known, of course, that algal and other growths are largely responsible for the choking of filters, and that in the majority of cases, if those growths can be checked or destroyed, the working life of the filters—that is, the lengths of the periods between cleansing—is prolonged. Yet, curiously enough, it would appear that the checking of one particular growth may foster and encourage the development of another growth which may, in its turn, interfere with filtration. Commenting on the matter in the present report, Sir Alexander states that when writing his twelfth report last year it almost looked as if the problem of being able to prevent choking of the filter beds with these growths had been solved. The destruction of the prolific Asterionella, or, at any rate, the holding of it in check for many months, had undoubtedly had the effect of lengthening the time during which certain filter beds could remain in useful operation. Unfortunately, however, it was discovered later that not only had the water in the reservoir taken on a greenish hue, but that the upper layers of the sand in the filters had acquired the same color, which, in fact, had penetrated some little way into the sand. Meanwhile no similar effect had been found in the laboratory investigations, for which filters composed of four thicknesses of fine linen were employed. Eventually it was discovered, however, that the trouble was due to vast quantities of an excessively minute growth known as Raphidium, which, though small enough to pass through four thicknesses of fine linen, yet had the effect of, in time, filling up the interstices between the grains of sand in the filter bed. Now it appears that that particular growth had never previously attracted attention at any of the Board's works, though other minute growths had been known to pass through the laboratory filters, and in speculating on the phenomenon Sir Alexander puts forward the suggestion that it is probable that the very fact of checking the growth of Asterionella had paved the way for the active development of Raphidium. It is difficult, as he has many times remarked, to foresee, when interfering with the laws of Nature, all the possible consequences.

Apart from such curious effects as that just alluded to, there are many other peculiarities in the behavior of stored water which for the most part have influence on filtration. It might well be supposed that, following the natural order of things, particular growths might be expected to develop at specific times and seasons of the year. Thus, as Sir Alexander points out, it is reasonable to look in the late winter and early spring, and again in late autumn, for a preponderance of such growths as Asterionella, Fragillaria, and Cyclotella. Yet, he continues, there is no adequate explanation forthcoming of the remarkable variations which may, and sometimes do, occur in a particular reservoir on the same date in different years. As a striking illustration, he cites the case of Island Barn reservoir water. A sample of that water collected on Aug. 30th, 1915, showed the presence in abundance of a growth known as Ceratium. Almost a year afterwards—to be exact, Aug. 28th, 1916—the water in the reservoir was found to be remarkably free from growths of any kind. A year later, almost to the day, Aug. 27th, 1917, the water contained quantities of little greenish felted masses, which are described as being "of an Oscillaria kind of growth," and which when magnified have very much the appearance of tufts of rabbit's fur. A year later—Aug. 26th, 1918—a growth of an entirely different nature—that referred to as "the beautiful Volvox"—was the predominating feature in the water of the reservoir. These three growths, absolutely distinct and differing as widely from one another as the proverbial chalk from cheese, had all, be it understood, made their appearance in enormous quantities in the same reservoir at precisely corresponding times in different years, while there was one year in the four in which, at the same season, there were practically no growths in the water at all. Nor is it only at the end of August that Island Barn water may have different growths in different years. On May 1st, 1916, the water was found to contain Tabellaria in great abundance, whereas on April 30th, 1917—a year later—it was, beyond the presence of a few Asterionella, almost free from any growths. Only 28 days later in the year, but in 1918, the water in this same reservoir took on a decidedly green tinge, which was due to a heavy growth of Protococcus. Treatment with copper sulphate failed to remove the trouble entirely, though the dosing was carried to a point beyond which it was deemed unsafe to go for fear of killing the fish, when it was stopped. Curiously enough, about two months later the water cleared very quickly, "and, as it were, spontaneously," to use Sir Alexander's own words, but the Protococcus was succeeded by a rapid growth of Cyclotella. The Island Barn reservoir is not alone in experiencing different growths at the same time in different years. During August last year a growth—Staurastrum—appeared in considerable numbers in the Staines reservoir water. The year before it had been the growth Glenodinium which had been specially prominent, though it was at its greatest development slightly earlier in the year than was the Staurastrum last August. Moreover, the same growths by no means always come to their greatest development at the same periods of the year. For instance, about May 14th last year there was a growth of Stephanodiscus in the Stoke Newington reservoirs. On that occasion copper sulphate treatment proved successful. It was six weeks or so later that the same growth made its appearance in the Hornsey reservoir, when the same treatment was efficacious. From an earlier report we find that in August, 1915, there was a very decided growth of Stephenodiscus—also in the Stoke Newington reservoirs. The visitation was then so considerable that the reservoirs were thrown out of service for about six months, and most of the water had eventually to be run to waste. It is noteworthy that copper sulphate treatment was not resorted to; indeed, the use of that chemical had not then, we believe, been adopted by the Board, at any rate to any great extent. These three examples show that one growth, at all events, can luxuriate and come to full development over a period covering a third of the year.

Many similar instances of how that algal and other growths do not always do what might be expected of them, and are not all amenable to the same treatment, might be adduced. But enough has been said to show that the matter is full of difficulties and surprises, and that it requires constant and unremitting attention if every emergency is to be met and countered with satisfactory results. So many factors have to be taken into consideration that with our present knowledge it would appear to be quite impossible to dogmatize. It is not so very long ago that the extended employment of storage reservoirs was hailed as a panacea for all water supply troubles. That sufficiently prolonged storage does, indeed, have a wonderfully purifying effect on water from the bacteriological point of view is beyond question, but it is unfortunate that the keeping of large bodies of water in storage reservoirs results in many cases in the development of growths which, unless kept well in hand, may play havoc with the filtration plant. Raw river water, as Sir Alexander Houston has frequently pointed out, contains so few living growths that any difficulty met with in filtration is largely due to the presence of amorphous dead matter. In some cases—notably with the Walton and Chelsea reservoirs—storage results in the deposition of these suspended matters, so that the water drawn off from the reservoirs filters without any trouble whatever. With other reservoirs, however, matters are quite different—but the reason why they are so appears to be doubtful, though whether the water is stagnant or in circulation in the reservoir may possibly have some effect—and the greatest vigilance has to be exercised if the best results from all points of view are to be obtained. Sir Alexander some time ago discussed the desirability of anticipating the development of the growths by treating the water with algicides in advance of the time when the growths might be expected to commence to grow in the ordinary course. Such preventive measures would most probably do good in the intended direction, but it is not absolutely certain that they might not engender trouble in another direction which might conceivably be even more harmful than the evil which it was sought to avert. Were it only necessary to destroy or to prevent the formation of known growths which appeared regularly at specific periods of the year, and were the same in all reservoirs, the problem would present but few difficulties; but, as we have shown, it is by no means as simple as that. In fact, so complex is it that one wonders whether in future we shall see a further extension of the chlorine treatment of raw river water, with possibly the employment of mechanical filters as an adjunct rather than the further multiplication of storage reservoirs. Sir Alexander briefly touches upon this side of the question in his latest report, but he leaves us in some doubt as to the progress he has made in his investigations. There is the comfortable feeling, however, that the matter can be safely left with him, with the full knowledge that every care is being taken to supply the metropolitan area with water that is pure when judged from every standpoint, while the cost of treatment is kept down to the lowest possible point.

"Lieu-Rates" and "Time and a Bit" Systems of Renumerating Labor

Editorial in Engineering, London, July, 1919.

On the subject of the remuneration of labor there remain still in force many of the provisions and extensions of practice introduced under the stress of war conditions, the effects of which are the opposite of conducive to increased efficiency; they place us in an unfavorable position as manufacturers for competing in the world's markets. These conditions are such that neither the men nor their unions will make the slightest move towards any alteration. The severe stress of war conditions naturally, and quite early in the rush to produce munitions, led to competition amongst employers to secure the services of the limited number of available workers so as to increase the productivity of their plant, to man the new machines and increased equipment installed, and to assist towards keeping their promises in regard to deliveries of the weapons of war so urgently called for by the many authorities, often competing amongst themselves for delivery. Not only was there competition to get men, but with the certainty of employment on application, there was the difficulty of retaining the men who might be induced to start. Rapidly the workers gauged the situation, and unless assured that their remuneration was above the standard, they moved elsewhere to better their conditions. To such an extent finally was this the case, that, none too early, legislation had to be introduced to limit such tendencies.

As a means to increased output, and especially applicable to repetition work, payment by results was earnestly advocated by the authorities, and in response extended adoption of the system took place. Such adoption was facilitated by the Munitions Act, and various agreements to which the Trades Unions subscribed.

In regard to most systems of payments by result, such as piece work, there will be no denying that the following two facts stand out quite clearly. Firstly, that with repetition work, the system can be applied most readily, and will show a great improvement on time work, and, secondly, that with such work, if the product remains substantially the same, even a slightly high price at the introduction of the system will lead with remarkable rapidity to earnings many multiples of the time rate of wages previous to the introduction of the system.

As is well-known, such earnings in the past have given rise to the practice of the cutting of rates. During the war two tendencies operated and should be noted. Due to the fact that many shops were engaged on a type of product of which they previously had little or no experience, and also to the lack of experienced piece price or rate-fixers to cope satisfactorily with the fixing of prices or times for the mass of work being turned out, prices which were exceedingly high were far from uncommon. The cutting of prices, a practice, the only excuse for which is ignorance, was practically impossible in this connection, because of the general difficulties with labor, the strong position of the labor organizations, the sympathetic appeal system that was introduced by the authorities to reduce labor discontent, either real or imaginary, and on account of the favorable terms that were offered to employers for the contracts placed on a fixed price basis, albeit the "time and line" system was quite generally adopted for new work, or in the case of firms of insufficient experience, to quote on a fixed price basis.

In what position, then, was a manufacturer whose work was of such a nature that payment by results could not readily be applied to a considerable proportion of it? How could he keep his men, when in an adjacent works, repetition work, and payment by results, with the high earnings generally accruing from such a state, was the rule?

There can be little contention that in all shops there is a considerable portion of the work that lends itself quite readily to system of payment by results, although on work of a non-repetition character the prices or times must be generously estimated if earnings comparable with those earned on repetition work, as has already been explained, are to be possible. Supposing this fact be recognized, there still remains a proportion of the workers who cannot readily be put upon payment by results, and there are the periods of time when the general payment by result workers cannot work on other than the time system of remuneration.

Such a state of affairs exists to a certain extent in shipbuilding and in lesser measure in marine engineering. To meet these conditions, the "Lieu-Rate" or "Time and a Bit" system was in vogue, principally in shipyards, even prior to the war. As its name implies, "Lieu-Rate" is an enhanced time rate given in lieu of piece work, as, for instance, on a new job, a price for which it is felt cannot be fixed. It may require very particular skill, and on this account it may well be desired to allocate to such work the best available workers, who normally, in all probability, make large earnings on piece work or a similar system. An arrangement is then made to the end that, either these men will be paid during the time they are so engaged at the same percentage over their time earnings as they have been receiving for a given period previously, or else on a fixed percentage over their time rates, called "time and a bit," generally time and a half. To expect workers under the conditions experienced during the war period to revert to plain time rates when on such work, would have caused them to seek the more remunerative piece work elsewhere; such was the demand for labor. There were shops in which no effort was made to work a system of payment by results. "Lieu work," or "Time and a Bit" offered the path of least resistence, giving high earnings and being thus favorably regarded by the men and their union officials. It was, in fact, simply a very much higher time rate than the district or the average rate, and so, on that account, not open to the objection lodged against payment by results. The efforts on the part of the management necessary to fix satisfactory and equitable piece rates or bonus times were not required.

The number of jobs in any shop that can be regarded as incapable of estimating with a view to fixing a price or bonus times, is in proportion to the number of ratefixers appointed for this work, coupled with the experience available, and is further dependent upon the degree of organization of management ct the work.

With a sufficient number of ratefixers possessing the requisite experience, the amount of work which cannot be priced may be said to be extremely small, provided the work is so arranged and organized that delays for want of material are infrequent, the appliances are adequate, and that men are not hustled from one incomplete job to another and so on. The question arises as to whether such an organization as is necessary, with a large staff of rate-fixers—and in many classes of work quite a large staff will be required to assess prices for all work being undertaken—will give value for the increased on cost resulting? If present-day practice be referred to, the answer would be in the negative, but the opinion is gradually gaining ground that competition in the future will force a more ready realization that the experiment must be boldly faced in the endeavor to reduce the selling price of our manufactures. In the United States of America this necessity is perhaps more generally recognized. If the alternative is "lieu-work" or "time and a bit," little trepidation in taking the step need be felt. These systems, however, are extremely expensive in wages cost per unit of output.

There remain a number of cases where the fixing of prices or bonus time is most difficult, as for instance, where the actual time required for the work is to some extent without the control of the management or the men concerned—such work, as, for instance, testing, where the testing time is dependent largely upon the requirement of an inspector, and is not capable of definite specification. Testing work can sometimes quite conveniently be made part of the contract of the erectors or fitters or can be a separate contract; although in such work the tendency under these conditions would be to hide defects, which at all costs should be brought immediately to light. Work of this nature could be paid for at a rate depending upon the rate earned on previous work, although the objections to such a system arising from a tendency to prolong the operation in question, etc., are obvious, and need not be enlarged upon. The question of the payment for work of this nature in a payment-by-results shop is not capable of ready solution, and merits the closest study, although only a subsidiary issue of the main subject of "Lieu Rates" and "Time and a Bit."

Such systems have been so extended during the war, and have in many quarters obtained such a firm footing that with competitive conditions again returning, the firmest stand must be taken completely to eliminate them. The path of least resistance in such matters can only lead in one direction—that of high labor costs and selling prices. We have previously urged, when dealing with payments by results, and can only again most strongly emphasize, the necessity for definite knowledge of all conditions before fixing prices or basis times. Men of high standing and technical qualifications must be trained and then placed in positions of authority to deal efficiently with the very complex subject of the fixing of piece prices, bonus times and allowances. By such a course only can we effect the change in some of our industries from the haphazard, rule-of-thumb methods of control of these matters of the past, to the more progressive and virile grip consequent upon putting into practice, in regard to remuneration in proportion to effort, the results of thorough and detailed investigation.

Compressed Gas for Motor Vehicles

Abstract of an editorial in Aug. 15, 1919, issue of Engineering, London.

Town gas as a propellant for internal combustion engine vehicles performed a useful function in the war, but it was mainly looked on as a makeshift, and with the coming of peace appears to have pretty well dropped out of use. Gas traction has been used earlier to some extent in connection with tramway propulsion, but the advent of the flexible container and the application of gas to petrol vehicles dates back only to the summer of 1916, when Messrs. Andrew Barton & Brothers began to run a single-deck Thornycroft motorbus between Beeston and Nottingham. This pioneer work was quickly followed up, and, as is common knowledge flexible containers were fitted in large quantities by vehicle owners who found themselves hampered by the shortage of petrol.

According to the Inter-Departmental Committee on Gas Traction, there were 5,000 gas-equipped motor vehicles in January, 1918, and by the following January the number had fallen to 3,600. The figure now is probably considerably smaller. As long as petrol is to be obtained it cannot be expected that gas traction will make any considerable headway unless it can be shown to have technical or economic advantages, but, in view of the national importance of using a home-produced fuel and restricting imports, it is desirable that the employment of gas should be fostered as far as possible, assuming, of course, that a reasonable case can be made out for it.

We have said that it is desirable to foster gas traction, since it represents employment of a home-produced fuel. None the less no amount of fostering is likely to lead to its considerable use unless a reasonable technical case can be made out for it. In this direction the report* of the committee we have already mentioned is promising. On the question of economy it is estimated that 250 cu. ft. of town gas are on the average equivalent to 1 gal. of petrol. The relative economy this ratio may stand for will vary enormously owing to the great variations in the price of gas, but as an example the Scottish Motor Traction Co. during 1918 ran over 1,000,000 miles partly on gas and partly on petrol. The total petrol cost, at 2s. 4¼d. (56½ ct.) per gallon, was £10,674, and the total gas cost, including cost of bags and attendants' wages, was £10,843. Debenzolized Edinburgh gas was mostly used and the price paid per 1,000 cu. ft. was 3s. 8¼d. (84½ ct.). The total fuel bill was £21,517, and had petrol alone been used, and reckoning 5 miles to the gallon, which agrees with the company's usual experience, the total fuel bill would have been £28,002. This shows a saving of £6,484 as a result of using gas. There was, however, a loss of earning power with gas owing to time lost in filling, which the company estimate cost £3,285, leaving a credit balance on the side of gas of £3,199 a year. These figures relate to a fleet of 40 motor-buses.

Other evidence was furnished by the Great Grimsby St. Tramways Co., who estimated that for every 1,000 miles run on gas they made a saving of 15l. as compared with petrol, and after meeting all charges. A large part of the gas supply they used had not been debenzolized, and they found 240 cu. ft. to be an average equivalent to 1 gal. of petrol. Some work with gas traction was also carried out by the London General Omnibus Co. On the Cricklewood-Victoria route experimental running was undertaken with compressed gas in cylinders. A compression pressure of 1,000 lb. per square inch was employed. The compression plant was of small capacity, being suitable for 10 vehicles, and was used intermittently, and it was found that the cost of compressing 1,000 cu. ft. of gas was 2s. 3d. (54 ct.). Taking gas at 4s. 4d. ($1.08), this made a total fuel cost of 6s. 7d per 1,000 cu. ft., which, against petrol at 2s. 4d. (56 ct.) shows a fuel saving of 29.5 per cent in favor of gas. It is pointed out that these figures quote petrol at the price ruling for large contracts and gas at ordinary consumers' rates. Were the figures on a common basis the ratio would show still more favorably for gas and obviously compression charges would fall with a large and continuously-running plant.

This possibility of using steel cylinders for the gas instead of flexible containers raises an entirely new aspect of this question. Anything else apart, it is obvious that the amount of room it takes up has always been an objection to the gas bag.

The commitee has given much attention to this question of the use of compressed gas and reports entirely in favor of it. They make some detailed recommendations in connection with the size and thickness of the cylinders and suggest working pressures up to 2,250 lb. per square inch. The cylinders when in position on the vehicle should be disposed within and totally enclosed by the bodywork of the structure. It is regarded as preferable that they should be recharged in position.

Some work has been done with wire-wound cylinders with removable metal end-plates held in place by screwed longitudinal tension rods of steel. The committee, however, do not recommend them, and find that there is leakage at the ends when the internal pressure falls below about 35 atmospheres. The cylinders are also heavier for a given volume of gas than high-carbon or alloy steel cylinders made according to the committee's specification. It is possible that a built-up cylinder of this class may be cheaper and more easily obtained when a small quantity only is required, but if gas traction comes into being on any considerable scale the drawn steel cylinder would probably prove the more convenient and cheap. As a further alternative to the flexible bag, the committee are, however, inclined to favor a semi-rigid container consisting of an inner member or tube in the form of a rubber container and an outer casing of woven steel wire. This class of container is approximately one-third the weight of a steel container for a given volume of gas, and as it stretches on being charged give ample warning if overcharging be attempted. As this type of container can be dropped on to the ground with impunity, and as, if overcharged, the inner rubber member bursts without the wire casing being fractured, the construction should prove very safe in ordinary practice. The weight saving as compared with a cylinder may be of great importance. A working pressure of 45 atmospheres is recommended.

The report with which we are concerned also deals to some extent with portable suction gas-producers for use on motor vehicles. This development is clearly a somewhat different one from that of the employment of town gas, but it has in common the facts that it employs a home-produced fuel and is more or less directly applicable to existing petrol-engines, lorries, etc. It is stated that portable suction producers are available which, after the necessary attention at lighting-up, can be made to work automatically, and that their fuel cost with coke at 45s a ton, or anthracite at 55s a ton, is equivalent to petrol at 5.4d a gallon. The weight of the generator and accessories for a 30 brake horsepower engine is about 220 lb. This certainly sounds a very attractive proposition. Some work was done with portable producers of this class before the war, but we do not know that they came into use to any considerable extent. The committee examined three appliances of this class, and they all showed close agreement as far as regards fuel consumption. The system due to Lieut. Col. D. J. Smith was subjected to the fullest tests, and a lorry fitted with a Smith producer was run in all 277 miles on the road. The installation was to some extent a makeshift one, owing to shortage of materials, and was too large for the lorry to which it was fitted, but the general results were good. This development of internal combustion traction would appear to be well worth attention.

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*Report of the Inter-Departmental Committee on the Employment of Gas as a Source of Power in Motor Vehicles.

The Mother of Invention

Editorial in The Engineer, London, Aug. 15, 1919.

A reflection which will bear investigation is that the progress of the world has been brought about by the ability of certain members of communities to make other members want something. We can imagine that the first prognathous individual who, by chance or cunning, chipped out a flint axe head set up a general craving for stone axes—save amongst the "laudatores temporis acti" of his day—which has led by various intricate processes to the multitude of cutting tools with which we are now familiar. In the absence of the stone axe the human race would have remained where it was—a guileless and reasonably contented people, wallowing in dirt, but free from political wire-pulling and as indifferent to the daily tragedies which prevented the increase of population as were the rest of the animal creation that surrounded it. The individual who thus opened the road to civilization acted without malice prepense, and has been forgiven, even praised, by men of a later age. He was certainly not an intentional reformer. He did not invent the flint axe head because he foresaw wealth from its exploitation; he did not, as most of us do today, set out with the intention of making others need his services. He whittled the flint because he liked whittling flints; he was, in fact, a pure industrial scientist. The thought of gain would have been hateful to him—until he saw it within reach, and then, like later pure scientists, he argued no doubt that the laborer was worthy of his hire. Today the course of the great mass of invention is very different. The great business on which we are all engaged is that of making some one else want something we can provide. Is not that the end and object of all advertisement, whether it be the blatant plastering of our national monuments with offers of a loan on advantageous terms or the more subtle advertisement of civil engineers through the media of scientific discussions? The inventor in the twentieth century thinks of two alternatives only—to create a want or to supply one.

No one has yet decided whether necessity always precedes invention or whether the invention makes the need, but it may be observed, with passing interest at least, that in a long period no revolutionary invention escaped opposition; there were always a great many people who were quite convinced that the world would get on just as well without it. The steam engine, the steam boat, the railway suffered opposition just as textile machines and machinery for many other purposes did. Even in recent times great inventions have been opposed. We recall the difficulties that Westinghouse experienced in persuading railways to adopt his brake, and the obstacles and resistance that beset motor transport, and do not forget that we have still amongst us conscientious objectors to vaccination and kindred inventions for the bodily welfare of mankind. Yet, take it for all in all, the world was never more ready than at the present moment to welcome the latest developments of applied science; there was never a time when the inventor had a greater prospect of succeeding. Moreover, the need for great invention was never more acute. Four years of lost labor have to be recovered. That object can only be achieved by accelerating the rate of output of everything man needs from his daily bread to his means of transport. But acceleration is hampered on the one hand by the resolution of one part of the community to do less work, and on the other by the excessive price it demands for the work it does consent to do. Labor refuses point blank to help the country. Can Science take the burden on its shoulders? Can it show once again the falsity of the socialistic doctrine that all wealth springs from manual toil? Coal is, of course, the first thought that springs to the mind. Can scientists by taking thought make one pound of coal do what two are doing? Can engineers devise new means of winning coal that will make colliers unnecessary? Some years ago that brilliant and always daring thinker, Sir William Ramsay, proposed closing the pits, firing the coal within them, and drawing off the gas for industrial use. The scheme was derided, on sound principles, in its day but with coal approaching three times its old price we look yearningly towards it. Again no one who has watched the rollers from the Atlantic advancing upon the ramparts of Cornwall, or has seen the rise and fall of the tide in the Wye and Severn, but has pondered upon the gigantic powers that need but the bit and bridle to replace coal as a source of power. In such things the inventor finds scope for his largest talents.

But amongst lesser economics there is as rich a field. In metallurgical practice the consumption of fuel in the blast furnace, in the open hearth, in the cupola, cries aloud for reduction. The introduction of the regenerative furnace caused a great diminution of coal consumption, whilst the profitable use of blast-furnace and other gases effects economies on a large scale. If it is impossible to look for similar inventions of equal magnitude, it is at least open to metallurgists to make greater use of those that exist. Not only in a few, but in all districts waste heat should be economized. Probably from Sheffield alone enough heat is dissipated continuously to the air to provide the whole of Yorkshire with power. For every ton of iron smelted in the blast-furnace it is estimated that heat units equivalent to twenty-five horsepower are discharged from the furnace-top; about half the total heat energy entering the furnace is lost in the gases either as sensible heat or as unburnt carbonic monoxide. In the open-hearth furnace not more than one-quarter of the heat units supplied are expended on heating and melting the charge, one-half is lost by radiation, and conduction, and one-quarter goes up the chimney. In the steam engine and turbine and in internal combustion engines we must be content to chase single percentages and fractions of percentages, but, in view of the fact that all save an insignificant amount of the power used in the United Kingdom is developed by heat engines, small fractions in the sum bulk large. The use of pulverized fuel opens new prospects in two directions; in one it offers better combustion, and in the other it opens the way to the use of fuel of poor quality. Here, if we may give play to our imagination for one moment, we see a new means of handling coal from the pits. At the shaft foot we see a group of pulverizers driven by gas engines crushing the coal to powder, and beside them a group of gas-power blowing engines driving the powder in a continuous stream up pipes into depositing chambers and thence into closed trucks at the pit's mouth. The coal is run-of-mine; it carries, too, a percentage of dirt, but the product is so mingled in the pulverizing process that the fuel as it issues is of a consistent quality. Economy is effected by the reduction of handling at the pit; by the greater weight that can be carried per cubic foot of wagon or bunker space, by the ease of handling; and, finally, by the economy of consumption.

But to descend from visions to more concrete problems. Although the internal combustion engine may be more nearly approaching the limits of thermal efficiency than the steam engine, there is still a margin to be conquered. Engineers have always recognized that heat units are wasted in its exhaust and in the water jacket that might be saved, and many plans have been tried, and some are used, for economizing them. But the extent to which such inventions are employed is relatively insignificant. Possibly the Still engine or the combination of gas engine and low-pressure steam turbine opens a road to the better utilization of the heat, or possibly the gas turbine is destined to effect economies in internal combustion motors equivalent to those effected by the steam turbine. In steam engines of all kinds we look to higher pressures with considerable hopes. Three hundred and fifty pounds have already been used, and pressures of five hundred are in contemplation. With each step upward in pressure new economies will be effected.

We see thus that there is scope for invention, and we may opine that necessity will encourage it, but the full fruits of such inventions and discoveries as men of science may provide will not be gathered by the United Kingdom in industrial conditions like those that now prevail

Burnt Earth Concrete, With Iron and Wood Reinforcement

By L. P HODGE.

From Engineering, London, Sept. 5, 1919.

The substitution of burnt earth for stone in concrete has no doubt received some attention in alluvial countries where stone is scarce and transport costly, but engineering literature contains very little, if any, information on the subject. The same remark applies to "ligno" concrete, i. e., that in which wood is substituted for iron reinforcement. An article on "Some Tests on Ligno Concrete," by C. A. M. Smith, in Engineering of Dec. 16, 1910, drew attention to its possibilities, but as long as iron and mild steel were easily obtainable at fair prices, engineers preferred to use them in preference to wood. Owing, however, to the large increase in the cost of imported metal due to the war, and to the difficulty of getting it, ligno concrete is now likely to come to the fore where conditions are favorable to its employment. The author ventures, therefore, to hope that the following tests of burnt earth concrete beams with both iron and wood reinforcement, and their successful employment in piles and abutment slabs, will be of practical assistance to those who may be desirous of employing similar materials.

Burnt Earth Concrete.—The earth burnt in British Guiana is generally the ordinary coast alluvium, the surface analysis of which is as follows compared with London brick clay:

Constituents.	Demerara clay.	London brick clay.
Silica crystalized	19.648	49.5
Silica combined	34.728	34.3
Alluvium	11.950	7.7

For reinforced concrete only clinkers were used, and after breaking they were screened through a 1-in. mesh and retained on a ¼-in. mesh, being thoroughly washed during the retention screening. The mixture was 1:2:4. The Portland cement used throughout was supplied to British standard specification. Sufficient for 12 neat briquettes was taken from 3 bbl.

The average breaking stress at 6 days was 428.5 lb. and at 28 days 508.5 lb. The average increase was, therefore, 18.7 per cent, or slightly under the 20 per cent required by standard.

Assumed Resistance to Compression.—As the bridges for which these experiments were undertaken were urgently required, it was desirable to test the beams not more than seven days after casting. To determine the probable ultimate compression of the burnt earth concrete at that time, so as to approximately apportion the material in the test beams, the author employed the formula deduced by Mr. Edwin Thatcher from his experiments for Mr. George A. Kimball, chief engineer of the Boston Electric Railway Company ("Trautwine," nineteenth edition, page 1106, paragraph 35).

$$S = M - N \times$$

where:

S = ultimate compressive strength in pounds per square inch.
X = number of parts of sand to 1 of cement.
M and N = values as below:

Age	7 days.	1 month.	3 months.	6 months.
M =	1,800	3,100	3,820	4,900
N =	200	350	460	600

$S = 1,800 - (200 \times 2) = 1,400$ lb. per square inch. The author decided to limit the safe stress at 7 days to 300 lb. per square inch = F of S, 4⅔.

Iron Reinforcement.—This consisted of unmarked rod iron, marked rods being unobtainable owing to the war. Its safe tensile strength was assumed throughout as not exceeding 5 tons per square inch.

Wood Reinforcement.—This was our indigenous greenheart (Nectandra redioci) of which the ultimate resistance to tension is stated to be for ordinary quality, 8,800 lb. per square inch. (Rivington's "Notes on Building Construction," Part IV, Table 1). Its safe tensile stress was assumed at one-fifth = 1,760 lb. per square inch. The ratio of substitution became therefore:

$$\frac{\text{Iron per square inch, 5 tons} \ldots\ \text{Lb. } 11,200}{\text{Greenheart per square inch} \ldots\ 1,760} = 6.4$$

The first experiments were made with sawn scantling which had not been soaked in water. Surface cracks developed in every case and thence, save in Experiment B, the wood reinforcement was immersed for 24 hours immediately before the beam was cast. The increase of weight due to absorption was as follows:

ABSORPTION OF WATER BY SAWN GREENHEART IN 24 HOURS.

Dimensions of specimen.	Weight before immersion, lb.	Weight after immersion, lb.	Increase, per cent.	Absorption per sq. ft of area immersed, lb.
12 ft. by 3 in. by 2 in. (used in experiment D)	31.0	33.5	8.06	0.248
Two pieces, each 5 ft. by 2 in. by 1 in. (used in experiment F)	8.0	9.5	18.75	0.298
Three pieces, each 5 ft. by 2 in. by ½ in. (used in experiment H)	6.5	9.0	38.46	0.399

From the above table it is evident that, as might be expected, the absorption of small sections very much exceeds that of large ones, being governed very largely by the surface area immersed.

Tests.—Two piles, two beams and four concrete planks having been designed in accordance with the preceding data, of ferro concrete and ligno concrete, respectively, were tested as beams, with the results shown graphically on the accompanying diagram. The following is a digest of the tests, the diagram being lettered to correspond.

DIGEST OF EXPERIMENTAL TESTS.

(Concrete of Burnt Earth 1:2:4 Throughout.)

A. Ferro Concrete Pile.—A pile, 25 ft. long by 12 in. by 12 in., reinforced with five rods of ¾-in. round iron, was supported at 10 ft. clear span, eight days after casting, and loaded with a distributed load up to 7,749 lb., or about half its estimated distributed safe load at that time, regarded as a continuous beam. It stood this test without taking a permanent set (see diagram A), and was subsequently transported 8 miles by dray, and successfully driven a month after casting.

B. Ligno Concrete Pile.—A similar pile, but reinforced with two bars of 2 in. by 2 in., and two bars of 2 in. by 3 in. greenheart in lieu of iron, was similarly supported and loaded at eight days, up to 7,755 lb., or about half its estimated distributed safe load at that time, regarded as a continuous beam, remaining thereunder for three weeks. Slight cracks appeared after loading, due probably to the greenheart not having been immersed before being placed in the concrete, but all deflection disappeared on removal of the load. Unfortunately, this pile was allowed to project too far beyond the dray during transit, and the elasticity of the greenheart, aided probably by lack of adhesion, due to the cause already stated, caused it to crack up in transport. A fresh pile was cast in situ, utilizing the same reinforcement after soaking it in water for 24 hours, and it drove as well, and is continuing to give as satisfactory results, as the ferro concrete ones.

C. Ferro Concrete Beam.—A ferro concrete beam, 12 ft. by 6 in. by 6 in., reinforced with two ⅝ in. rods, was tested at seven days, ends supported, at 10 ft. span. The safe distributed load of this beam was calculated at 1,371 lb. at that time. It collapsed under 2,249 lb., the tension rods being reduced by about 1/16 in. diameter.

D. Ligno Concrete Beam.—A similar beam, but reinforced with a 3-in. by 2-in. greenheart scantling, collapsed under 2,039 lb., by the failure of the reinforcement in tension. This beam failed with only 10 per cent less load than its ferro concrete competitor.

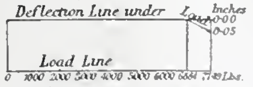
E. 3-in. Ferro Concrete Plank.—A ferro concrete plank, 12 in. by 3 in., reinforced with five rods of ¼ in. diameter, and loaded as a beam, one end supported, the other continuous, at 3 ft. span, bore 1,657 lb. distributed, at seven days, without permanent set. (Estimated D. S. L. at that time 1,512 lb.)

F. 3-in. Ligno Concrete Plank.—A similar plank, but reinforced with two laths of 2-in. by 1-in. greenheart, similarly supported at the same span, broke with a distributed load of 2,627 lb., at ten days, owing to the failure of the reinforcement. (Estimated D. S. L. at that time 1,955 lb.)

G. 2-in. Ferro Concrete Plank.—A ferro concrete plank, 12 in. by 2 in., reinforced with four rods of ¼ in. diameter and loaded as a beam one end, supported the other continuous, at at 3 ft. span, bore 605 lb. distributed, at seven days, without permanent set. (Estimated D. S. L. at that time 700 lb.)

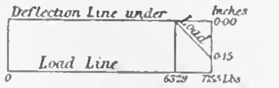
H. 2-in. Ligno Concrete Plank.—A similar plank, but reinforced with two laths of 2 in. by ½-in. greenheart, similarly supported, at the same span, broke with a distributed load of 1,432 lb., at 14 days, owing to the failure of the reinforcement. (Estimated D. S. L. at that time 733 lb.)

(A) FERRO CONCRETE PILE TESTED AS A BEAM ENDS SUPPORTED AT 10'0" SPAN; 8 DAYS AFTER CASTING.



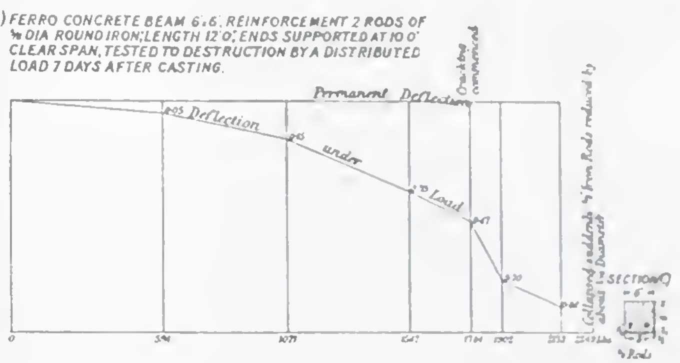
(A) No Permanent Set.

(B) LIGNO CONCRETE PILE TESTED AS A BEAM; ENDS SUPPORTED AT 10'0" SPAN; 8 DAYS AFTER CASTING

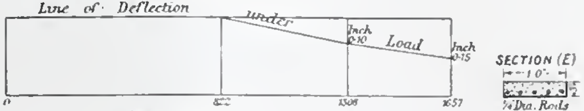


(B) No Permanent Set, Load remained 3 Weeks.

(C) FERRO CONCRETE BEAM 6"x6". REINFORCEMENT 2 RODS OF ½" DIA ROUND IRON; LENGTH 12'0"; ENDS SUPPORTED AT 10'0" CLEAR SPAN, TESTED TO DESTRUCTION BY A DISTRIBUTED LOAD 7 DAYS AFTER CASTING.

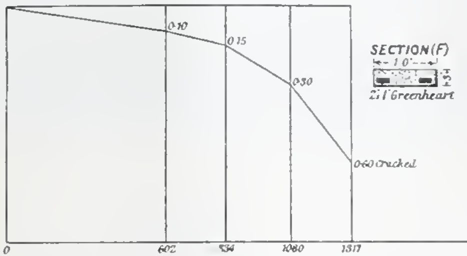


(E) FERRO CONCRETE PLANK 12"x3", TESTED AS A BEAM, ONE END SUPPORTED. OTHER END CONTINUOUS, AT 3'0" SPAN. DISTRIBUTED LOAD AT 7 DAYS AFTER CASTING.

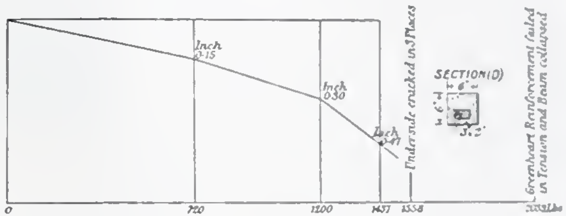


(d) No Permanent Set

(F) LIGNO CONCRETE PLANK 12"x3" TESTED TO DESTRUCTION AS A BEAM, ONE END SUPPORTED, OTHER END CONTINUOUS AT 3'0" SPAN DISTRIBUTED LOAD AT 10 DAYS AFTER CASTING.



(D) LIGNO CONCRETE BEAM 6"x6" REINFORCEMENT 1 BAR OF GREENHEART 3"x2", LENGTH 12'0"; ENDS SUPPORTED AT 10'0" CLEAR SPAN; TESTED TO DESTRUCTION BY A DISTRIBUTED LOAD 16 DAYS AFTER CASTING.



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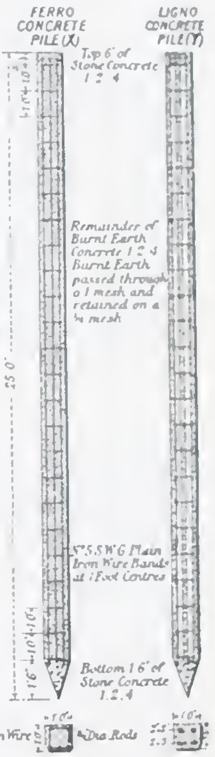
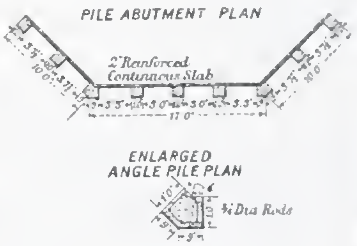
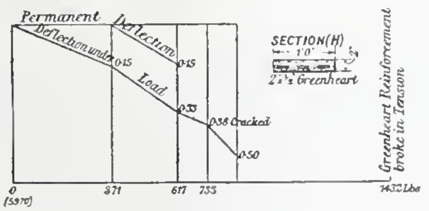
Extreme Fibres of Greenheart Reinforcement failed in Tension. Protective Concrete fell and further Fibres failed successively until Beam collapsed.


FERRO CONCRETE PILE (X)
LIGNO CONCRETE PILE (Y)
Top 6' of Stone Concrete 1 2 4
Remainder of Burnt Earth Concrete 1 2 4 Burnt Earth passed through a 1 mesh and retained on a ¼ mesh
25'0"
No 5 S.W.G Plain Iron Wire Bands at 1 Foot Centres
Bottom 1'6" of Stone Concrete 1.2.4
No 5 S.W.G Plain Iron Wire Band.
1'0"
¾ Dia Rods

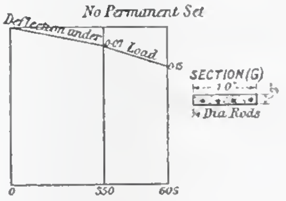


(H) LIGNO CONCRETE PLANK 12"x2" TESTED TO DESTRUCTION AS A BEAM, ONE END SUPPORTED, OTHER END CONTINUOUS AT 3'0" SPAN. DISTRIBUTED LOAD 14 DAYS AFTER CASTING.



(G) FERRO CONCRETE PLANK 12"x2" TESTED AS (H) AT 7 DAYS AFTER CASTING.

No Permanent Set



Practical Tests.—Seventy-two of the piles shown in the diagram (71 of ferro concrete and 1 of ligno concrete) were driven about 17 ft. through clay after one month from casting. None failed, or had to be re-cast, save the first experimental ligno concrete pile previously referred to. There are nine such piles in each bridge abutment (vide abutment plan), and they carry a maximum motor load of 2 tons per axle on an 8-ft. wheelbase, over a maximum span of 22 ft. They were driven with an 18-cwt. ram, the tops being protected by a canvas pillow, 10 in. square by 4 in. deep, stuffed with sawdust, upon which was superposed a hardwood dolly, 18 in. long by 12 in. by 12 in., to take the impact.

The reinforced concrete at the back of the piles was cast as a 2-in. continuous slab, the spacing of the ¼ in. diameter reinforcement lessening from 3 in. centers at the bottom, where the average depth of clay to be sustained is 8 ft., to 6 in. at the top, where the maximum depth is about 2 ft. below the crown of the road surface.

Conclusions.—From his experiments and practice the author arrives tentatively at the following conclusions:

1. Well burnt earth can be substituted for stone in concrete with safety and advantage when the cost of stone is prohibitive.

2. Hardwood can be substituted for iron or steel reinforcement with advantage in fairly large sections when, as is the case in British Guiana at present, the cost of iron is prohibitive. But in sections of small depth, the cost of converting the wood into thin strips, and the difficulty of so placing them as to get sufficient tension, and at the same time sufficient surface protection, outweigh its advantage.

3. Wood so employed should be immersed in water for at least 24 hours immediately before being placed in the concrete.

4. The most suitable wood having regard to its ultimate resistance to tension, and particularly to its uniformity, would appear to be greenheart (vide Rivington's "Notes on Building Construction," Part IV, Table 1), the available quantity of which in British Guiana will be inexhaustible for many years

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Tar Macadam Shoulders for Tramway Tracks.—A large yardage of tar macadam has been laid on the margins of tramway routes in Sheffield, England. In a discussion at the last annual meeting of the Institution of Municipal and County Engineers, Mr. W. J. Hadfield, Municipal Engineer, said that in almost every case this work has proved successful. He stated that this was due partly to the use of the steam roller. They rolled the road as hard as possible, and gave the tar macadam as long as possible to mature. Where the traffic was too heavy for tar macadam margins clinker asphalt mixed with bitumen was used. They had laid many thousands of yards of that material during the war. They laid a small batch some three years ago on a very busy street. The width of the roadway was 12 yd., and in addition to about 1,200 cars which passed over the tramways there was traffic amounting to more than 6,400 tons per day. The material, said Mr. Hadfield, was still as good as new, and they were now adopting the principle very widely.

Long Life of Watt's First Commercial Pumping Engine.—The earliest pumping engine made for sale by James Watt was under steam on Sept. 17th and 18th, when it was visited by engineers who attended the Watt Centenary Commemoration. Watt went into partnership with Matthew Boulton at Birmingham in 1775, and the Birmingham Canal Co. bought the engine in 1776, and it was working regularly from that date until 1892—112 years of active life. The engine was re-erected at Ocker Hill, near Wednesbury, in 1898.

British Excavating Machinery

By A. E. COLLINS,
City Engineer, Norwich, England.

From Water and Water Engineering, London, Sept. 20, 1919; Abstract of a paper presented at the annual meeting of the Institution of Municipal and County Engineers.

The great increase in cost of manual and team labor and the objections often made by workmen to laborious work render it necessary to search in all directions for efficient machinery to supplement and assist them.

This paper has for its object the direction of attention to machinery applicable to sewer and such-like trenches in particular.

The machines described divide themselves into two classes:

Class I comprises such as facilitate manual work by hoisting the excavated materials, conveying them for back-filling or filling carts and conveying and lowering materials. Class II comprises machines which excavate the trenches and deposit onto dumps or into carts.

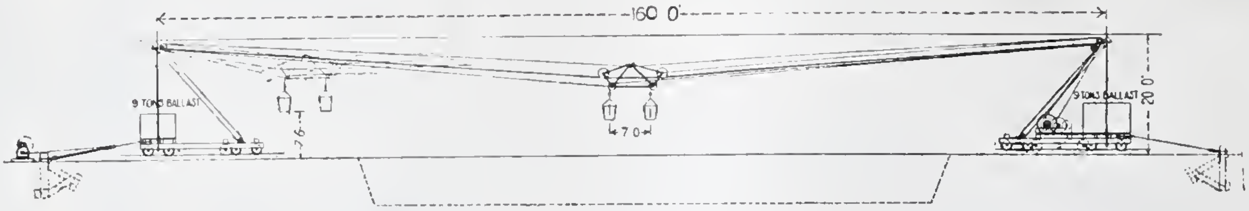

Fig. 1—Sewer Trench Cableway—J. M. Henderson & Co., Aberdeen.

The Blondin Machine.—A variety of the Class I machine is on the "blondin" principle, which is so largely used for quarrying, viaduct building, etc. This consists generally of a steel wire main cable suspended between two towers; on the main cable runs a load-carriage supporting a hoisting block. A double-drum winding engine operates ropes for hoisting and conveying.

An objection made to the "blondin" type of machine is the loss of time and inconvenience due to the necessity of taking down and re-erecting the machine each time it is necessary to move it forward.

The author has sought to overcome this objection to the "blondin" type for sewer and trench work by adopting an arrangement avoiding the necessity of taking down and re-erecting each time the limit of its length of command is reached, which is a troublesome business where wire ropes are concerned. Fig. 1 illustrates his scheme now under construction by Messrs. John M. Henderson & Company, Aberdeen, and adapted to that firm's make of machine.

This shows an electrically operated "blondin" in which the towers are built on trucks running on a rail on each side of the trucks also supporting counter-balances; a capstan barrel is provided which enables the machine to be drawn forward by its own power when the tail mooring is slackened. Both ahead and behind are timber mooring cables attached to ground anchors for moving purposes and to hold tower trucks at the desired points. After moving and before proceeding to hoist the wheels are chocked. While in use on a trench the machine is supported on flanged wheels running on rails; when being moved from place to place the machine is unrigged, the towers lowered, and it is run on road wheels of larger diameter than the flanged wheels. The cost of this machine is £1,100, or with its supporting rails, about £1,150. Six skips are used, two pairs being in the bottom filling and one pair in transit or tipping. Where tramway span wires are met with they will in general be temporarily disconnected to enable towers to pass; where this is inconvenient the towers will be lowered sufficiently for passage without unrigging the machine. The "blondin" machine imposes no weight on the sides of the trench, which in many cases is of great importance; as in the case of the trestle machines, it limits the necessary constructional area and assists in organizing the work. Also, in common with the trestle, it can be used for lowering and pulling out timber and such like, but by reason of the higher command of the "blondin" type it is more useful for this work.

Trench Excavators.—Passing to Class II machines—i. e., those which excavate the trenches—the first machine of this sort seen by the writer was at work on the Ormesby sewerage, on which he was called in as consulting engineer when difficulties arose. It was designed by Mr. Glover, M. A., M. Inst. C. E., managing engineer to Messrs. Monk & Newell, contractors, Bootle, and did very satisfactory and economical work; but, for some reason the writer never understood, the engineer for the sewerage scheme objected to its use. The machine was built by Messrs. Ruston, Proctor (now Ruston, Hornsby) & Co., Lincoln. The general features include a framing or carriage running on rails and supporting the motive power which operates a single chain-drum. From the front of the machine projects a gallows which supports at any desired height the lower end of a pair of girders hinged to the gallows at its upper end, and continued by girders fixed to the framing to above the dumping-place. On these girders slides a heavy dredging bucket fitted with tines on its cutting edge. Supposing the bucket to be at the bottom of its cut and resting heavily upon the ground, by winding the chain the bucket cuts into the ground and is dragged through it and along the pair of girders, and eventually up the upper girders to the dumping-place, where the locking and hinging arrangement of the bucket enables it to fall into the emptying position, and it dumps its load into a truck-cart, or on to the ground. When used on sewer trenching the carriage and framing straddle the trench instead of being at right angles to the work.

Messrs. Ruston & Hornsby, Ltd., do not now make this machine, but adapt their "Ruston" No. 8 steam crane navvy to digging trenches (Fig. 2) by the removal of the wheel under-carriage, mounting the machine on a special structure which straddles the trench, and providing a much longer set of bucket arms. In stable ground which will stand for half an hour or so without timbering, and where there is not much obstruction by water-pipes, etc., such a machine is likely to be economical. The trench can be timbered immediately in advance of the machine. This machine imposes a load on the sides of the trench it has excavated.

Whitaker Trenching and Tunneling Excavators.—Figure 3 shows the general arrangement of a Whitaker trenching machine, D. Whitaker, 1 Union Street, Leicester, as used by the British in France. These machines can be adapted to cut any width of trench from 18 in. to 54 in. wide; special machines can be built for greater widths. The machine shown cost £2,600, weighs 13 tons, and cuts a trench 10 ft. deep; machines can be built for greater depths.

Trenches curved in plan can be cut. Cross traveling bands can be attached to deliver spoil to a spoil bank parallel with trench on to a light auxiliary machine for back filling; a further machine rams the filling solid. These two machines require three men to work them, and cost ½d (1 ct.) per cubic yard hack filled and rammed. A very similar machine working in builder clay cut a trench 5 ft. x 2 ft. 3 in. wide x 150 ft. long per hour (62.5 cu. yd. per hour) at cost as follows:

COST PER 10-HOUR DAY FOR 625 CU. YD. EXCAVATION.

Oil engine, 30 B. HP.

	£	s	d
Petroleum, 0.85 pint per hp. at 1s 3d per gal.	1	19	9
Cylinder oil at 5s per gal.	0	2	6
Journal oil at 2s 8d per gal.	0	0	4
Grease	0	1	0
Driver	0	10	0
Laborer	0	1	0
Interest, 5 per cent on outlay, £2,600, assuming 300 working days per year	0	8	8
Depreciation, 12 per cent	1	0	9½
Upkeep, £50 per year	0	3	4
Total cost per day of excavation	£4	13	4½

Total cost per cu. yd., 1.79d (3.58 ct.). Pound (£) = $4.86; shilling (s) = 24 ct.; pence (d) = 2 ct., American money.

The latest machine does the work at 1.54d (3.08 ct.) per cubic yard. The cost per cubic yard does not vary materially with the depth; the shallower the trench the faster the machine progresses.

The tunneling excavators were designed and made for tunneling under the enemy lines. The general arrangement is that of a center of diameter of excavated tunnel, driven by an electric motor. Its working is as follows: A shaft is sunk of the required depth; the machine is lowered therein and set on rails, wood or otherwise. The cutting head is revolved by electric motor, and the conveyor starts simultaneously. Then the traveling gear is operated and the machine cuts its own way into the face. As soon as it has advanced 1 ft. 6 in. a set of laggings of circumference of tunnel is inserted 16 in. in length of tunnel. These are arranged in four segments; the last, or keying one, is short, and arranged as a wedge. The running rails form part of bottom segment. The segments are arranged so that longitudinal joints are staggered. The machines have been made to bore tunnels from 5 ft. diameter up to 20 ft.

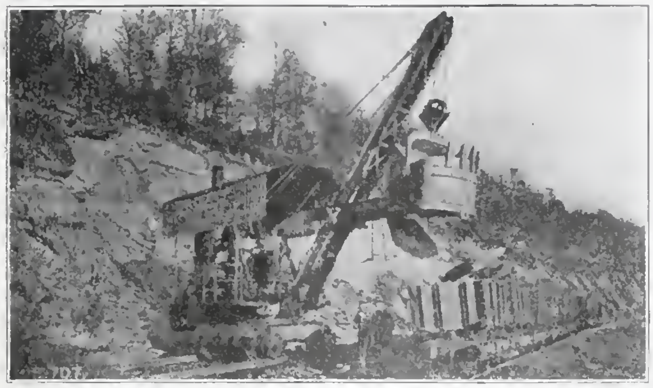

Fig. 2—Ruston No. 8 Steam Crane Navvy, Working in Heavy Shale.

The designed advance is 2 in. per minute for all sizes, the electric motors varying in power to suit diameters.

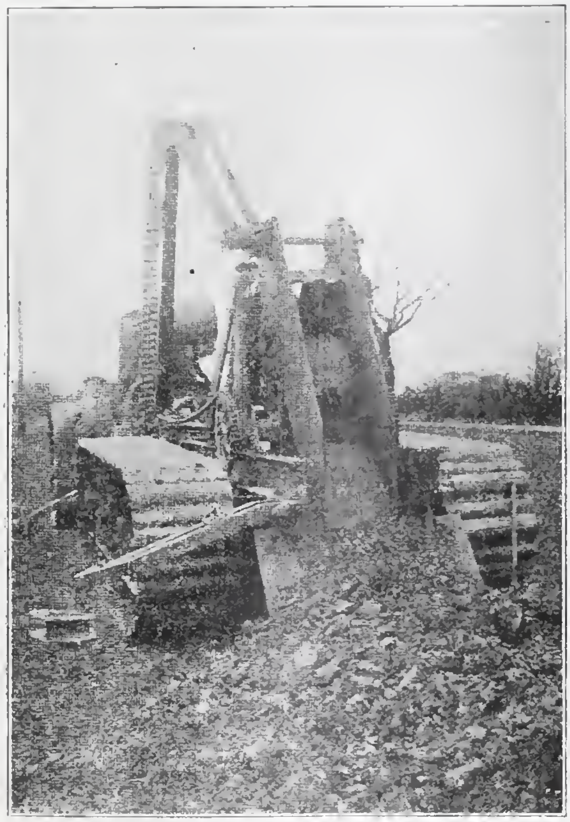

Fig. 3—Whitaker Trenching Machine.

The costs per hour, on a trial run cutting a 7 ft. 2 in. tunnel in Dover chalk, averaging 3.75 cu. yds. per hour, were:

	s	d
Electricity	4	8
Oil, etc.	0	6
Charge hand	1	6
Eight laborers	8	0
5 per cent interest on £1,600 at 300 days a year and 10-hour days	0	6½
12 per cent depreciation on ditto	1	3½
Upkeep	0	6½
Total cost per hour	17	0½

which equals 4s 6d per cubic yard finished and lagged tunnel (less lagging). Increasing speed to 2 in. per minute reduces cost to 2s 3d per cubic yard. In ordinary working five laborers and one charge-hand only are necessary, reducing hourly cost to 14s, or 1s 10½d per cubic yard at 2 in. advance per minute.

In reply to a short discussion on his paper, Mr. Collins said the reason why machines of this class and other labor-saving machines emanated from America and not England was not because the Americans had any greater ability in designing such machines, but because there had been a demand in that country for them, and the workmen welcoming the use of them. He had found that the men were proud of the machines and were anxious to get the best out of them. He had seen them at work in Montreal and at Vancouver they attempted to make the machine do its utmost. There they employed a low class of labor in the bottom of the trench, and a higher class at the top. With these machines one could employ a low grade of labor on work suited to it, leaving the more skilled labor to be used to better advantage. The question had been raised as to how these machines could be introduced in Great Britain. Of course, one knew that the vast majority of local authorities could not face the capital cost of such appliances, and, even if they could, would experience difficulty in finding work to keep them employed. It appeared to him that syndicates must be formed to contract for the work at a lower cost than would be possible ordinarily.

River Discharge

By HERBERT CHATLEY,

From Engineering, Sept. 5, 1919.

In the course of investigations made for the Whangpoo Conservancy Board during the past three years as to the regulation of the Whangpoo and Yangtze Rivers, the writer has had an exceptional opportunity to compare the various discharge formula with actual results on large streams with irregular flow. The results obtained appear so important that the writer ventures to think they are worth publishing.

In the first place, it appears from the observations that all the standard formula have no applicability whatever to natural sinuous and irregularly sectioned streams because of the "dissipation" losses at the bends and changes of section. The energy so lost may easily amount to as much as the friction head obtained from formula.

Secondly, it was found that in fairly straight and uniformly sectioned reaches when the flow is steady the exponential form:

$$V = C \, . \, R^{0 \cdot 7} \, . \, I^{0 \cdot 5} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

gives consistent results, l being the local slope or tangent to the water surface at the measuring section.

Thirdly, it was found that when the flow was unsteady in regular channels, the velocity followed a form:

$$V = C \, R^{0 \cdot 7} \left(1 - \frac{a}{g} \right)^{0 \cdot 5} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where a is the acceleration. In other words, the effective slope is equal to the algebraic difference between the actual slope and an "acceleration" slope determined by the ratio of the actual mean acceleration of the water to the gravitational acceleration.

It appears then that—

1. No advantages are obtained by using the complex Bazin, Ganguillet and Kutter, Hessle or similar formula, as the unavoidable errors of measurement and the irregularities which occur in even a very short length of a natural river, cause variations greater than the differences between these formulæ so that the mathematical advantages of the exponential form render it the most suitable.

2. In long reaches the energy dissipated in the creation of lateral induced currents and eddies at bends and changes of sectional form may be as great as the bed friction, so that formulæ are of no value except for short straight reaches with fairly uniform cross section.

3. The rise or fall of the "stage" introduces an appreciable "acceleration slope" which must be allowed for in the formulæ.

The Geology of Concrete Aggregates with Special Reference to Texture

By PROFESSOR P. G. H. BOSWELL.

From Concrete and Constructional Engineering, London. Abstract of a paper read May 22, 1919, at the 88th Ordinary General Meeting of the Concrete Institute.

The essential constituents of concrete are the aggregate, or lumps of broken materials, and the matrix, or binding substance, which is usually cement or lime. Frequently sand is also added to the mixture, or a fine-grained concrete may be made from sand and cement alone. The American connotation of the term "aggregate" includes sand.

In the specifications of the British Fire Prevention Committee the aggregates listed have been divided into two classes, natural and artificial. All the natural aggregates are necessarily rock substances, the description and occurrence of which come within the purview of geological science. The artificial aggregates result either directly, or as by-products, from the applications of industrial processes to geological materials. The natural aggregates include gravel (ballast), igneous (or fire-formed) rocks such as granite, basalts and other lavas, pumice, etc., and sedimentary rocks like sandstones, quartzites, limestones, etc., which were originally deposited under water or by wind, but which may have been subsequently altered by earth stresses or heat. The artificial aggregates include coke breeze, clinker, blast furnace slag, brick and terra cotta, and burnt clay. Materials analogous to all these artificial aggregates occur among the rocks of the earth's crust and have been produced in each case by the action of heat upon pre-existing rocks.

It is, however, with the geology of natural aggregates which are used, except perhaps for the crushing, screening and washing, in the state in which they are wrought) that the following notes are concerned.

The Classification of Natural Aggregates.—In the specifications of the British Fire Prevention Committee* a not entirely inappropriate grouping (so far as use is concerned) of natural aggregates is made. Broken stone is classified thus:

Ballast (gravel).
Volcanic rocks—(a) Basalts and dense rocks.
(b) Lavas.
(c) Pumice.
Granite.
Sandstone, limestones, quartzites, etc.

A more natural grouping of the specified rocks, however, would be:

A. Sedimentary rocks.
  (1) Sand.
  (2) Ballast (gravel).
  (3) Sandstones and quartzites.
  (4) Limestones.
B. Igneous Rocks.
  (5) Granite and other plutonic rocks.
  (6) Hypabyssal rocks, such as trap, whinstone (dolerite), etc.
  (7) Compact volcanic rocks such as basalt.
  (8) Vesicular lavas, pumice, etc.

Texture of the Aggregate.—For concrete making it is of importance as well as interest to know how coarse in texture the rock fragments may be and the character of their fractured surfaces. The latter depends upon their mineral constitution, which may also affect the setting of the cement. Other questions, which are concerned, for example, with binding qualities, dust-production, etc., have also to be considered.

We may now examine briefly the textural qualities displayed by the various rock types used as aggregate.

A. Sedimentary Rocks.

Sand.—The texture of sand, which is frequently used in addition to other aggregate, is considered separately in a later section of the paper.

Ballast (gravel) is usually incoherent, as in the case of "Thames ballast." The question of cementing material therefore does not arise. Many of the pebble beds used for concrete-making are of comparatively recent geological age. To destroy the uniformity of size and roundness, the pebbles should be broken before use in concrete work.

Sandstones and Quartzites.—Sandstones and quartzites are the indurated rocks corresponding to sands. The cementing material may be—

(1) Silica itself, as in siliceous sandstones and quartzites.

(2) Clayey matter as in argillaceous sandstones (which upon metamorphosis yield micaceous quartzites or quartz-schists).

(3) Oxide of iron, either as hematite ($Fe_2 O_3$), which is red; or limonite, which is hydrated and is yellow or brown ($2 Fe_2 O_3, 3 H_2 O$).

(4) Calcium carbonate, as in calcareous sandstones, or dolomite ([Ca, Mg] Co_3) as in the well-known Mansfield building stone.

(5) Other less important minerals such as phosphates, fluor-spar ($Ca F_2$), barytes ($Ba SO_4$), etc., which do not concern the concrete maker intimately.

Of the above siliceous is undoubtedly the best for the purpose now being considered. It is generally accepted that soft sandstones are to be avoided for concrete; practically speaking, the bond is rarely siliceous in soft sandstones. The matrix of silica leads to great strength and clean sharp fracture of the rock, firstly on account of its hardness, and secondly because the silica frequently grows crystallo-graphically on and in optical continuity with the surface of the quartz grains (being of the same chemical composition). The individual grains thus grow until they meet one another and interlock firmly. The structure can best be seen in polarised light under crossed nicols. Rocks of this character break across the sand grains and matrix equally and yield smooth plane surfaces and sharp edges. Soft sandstones may also be converted into quartzites of this type by re-crystallizing effects of heat, or of earth stresses during mountain-building movements. Such quartzites would belong to the metamorphic class of rocks.

Cementing by argillaceous matter does not yield the best type of sandstones for aggregate, nor do the results of matamorphism upon such rocks yield a satisfactory product (see below). The latter is often a mica-schist or similar foliated rock.

Certain workers at the subject have stated that, far from being inimical, iron oxide in rocks may be useful on account of the chemical reactions into which it enters with the cement. Unfortunately most sandstones cemented with this substance do not show a desirable degree of compactness; a few, however, such as the Carstone of the Lower Greensand, particularly from Norfolk to Oxfordshire, are fairly hard.

Calcareous cements may be chalky and amorphous in character (when the resulting rock is soft) or composed of crystalline calcite (when a hard compact stone may be yielded). In the latter case, as in quartzites, the fracture of the stone breaks across the sand grains and not round them—a very desirable property in concrete making. Occasionally "in the field" we meet with natural concrete—known as "calcrete" formed by the cementation of sands and pebble beds by lime originally in the form of carbonate. The matrix frequently shows no effervescence at the present time with acid, tricalcic silicate having probably been formed, as in the setting of cement. Calcite can be scratched with a knife; quartz quartz cannot. Aggregate of calcareous sandstone therefore shows heterogeneity in hardness as well as composition.

Portland cement containing more than 8 per cent of magnesia is objected to on the grounds that expansion and loss of strength are likely to occur in the course of time. It would therefore appear that sandstone cemented with dolomite should, if possible, be avoided.

Limestones.—Limestones may be produced by organic action or by chemical precipitation from the waters of lakes and seas.

Soft limestones are not suitable for concrete making, nor, on the whole, are those of organic or oolitic origin. They tend to break and flake irregularly, and an oolite rarely breaks across the grains. Crystalline limestones have a sharp clean fracture and are homogenous, but glide-planes are very easily set up in calcite crystals by pressure. Calcite has also an excellent cleavage; deformation and fracture are thus liable to take place. Limestone is neither as hard, nor structurally as strong, as quartzite.

B. Igneous Rocks.

Granite and Other Plutonic Rocks.—Whereas most sedimentary rocks consist of grains cemented together by chemically similar or dissimilar material, igneous rocks, from their very mode of origin, are made up of grains of minerals crystallized together. Various types of structures are produced, but the essential feature is the close contact and interlocking of the grains.

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*The writer understands that these specifications are at present undergoing entire revision. The results, however, are not yet published.

The plutonic rocks, having cooled slowly and often under great pressure, are coarse-grained and the individual minerals are on the whole equi-dimensional. This texture has been termed granitic from its being exhibited so frequently by granites. Where the individual minerals tend to take a somewhat rounded shape and uniform size, the texture has been called granular. In the diorites the grain is as a rule smaller than in granites. The constituent minerals of a typical granite are quartz, felspar and mica; hornblende and pyroxene may also be present. Quartz is much harder, and less prone to chemical decomposition, than the other minerals mentioned. Although these differential qualities might affect the value of crushed granite as a concrete-making material, most writers on the subject see little difference in the results yielded by granite and diorite, which is largely composed of felspar and hornblende or pyroxene, minerals more similar in hardness and in proneness to decay.

Hypabyssal Rocks.—Many of the "traps" and "whin-stones" are finely granular in texture, the individual crystals being too small to be seen by the naked eye. Occasionally there are larger crystals, known as phenocrysts set in a fine groundmass of small crystals. The structure is then known as porphyritic. The phenocrysts are large enough to be detected in hand specimens of the rock. Another structure frequently shown by members of this group of rocks is that known as "ophitic" from its snake-like appearance. During cooling, one of the minerals has crystallized out in aggregates of somewhat lath-like form, which interlock with and wrap round other constituents of the rock. Frequently either of the aggregates behaves under polarized light as an optically continuous crystal. The minerals, felspar and augite (pyroxene), which are commonly the constituents of dolerites, exhibit this feature well. Undoubtedly ophitic structure leads to density, sharpness and cleanness of fracture, and strength in concrete-making aggregate. Dolerites, traps, and whin-stones are therefore popular materials. Microgranites are the hypabyssal equivalents of the granites and show a fine-grained granitic structure.

Compact Volcanic Rocks.—The important members in this group, arranged in order of decreasing silica-content (and therefore of increasing specific gravity), are Rhyolites (and also Obsidians and Pitchstones), Trachytes, Andesites and Basalts. Rhyolites and Trachytes are frequently not as compact as the others; moreover, although they have been employed, they are of too limited distribution in the British Isles to be used extensively for aggregate.

Vesicular Lavas (Pumice, etc.).—The decrease in pressure which accompanies the extrusion of a lava at the surface of the earth results in the release of contained gases, steam, etc., which render the upper part of the flow frothy, and cause the bulk of the rock to be riddled with steam-holes, known as vesicles. Often these are drawn out into almond-shaped cavities by the sluggish flow of the congealing rock. The cavities may be filled in subsequently by minerals which have crystallized from solution (amygdales, amydaloidal structure). The fracture of such rocks is irregular, and the voids are great.

Metamorphic Rocks.—It does not appear that apart from quartzite and crystalline limestones, rocks of metamorphic origin have ever been extensively used in concrete work. They are not specifically mentioned in British specifications; in the American connotation of the term "granite," however, both gneiss and mica-schist are included.

Sands for Concrete Making.—Sand may be regarded as an aggregate itself or as a third constitutent in concrete. It is used so extensively for mortars and concretes as to justify a separate treatment. Materials like sand, loam and clay are as much rocks to the geologist as granite and basalt.

Sand plays the role in concrete-making of a filling material intermediate in size between the aggregate and the cement. It therefore tends to assist the production of smooth surfaces. To obtain a minimum of voids and a maximum of strength the gradation of the sizes present in the aggregate should be as perfect as possible. Any attempt to carry this proportional spacing of weights of aggregate over grade-sizes down to sand would lead to the production during crushing of large quantities of dust and fine material. Much washing would therefore be necessitated. It is more advantageous to break and screen the aggregate down to the size of very coarse sand and to fill in the smaller voids with coarse and medium sand (50 to 20 or 30 mesh). Fine sand has been found to weaken the strength of the concrete. On the same principle (of perfect spacing of grades) it is desirable that the sand used should not be "well graded," that is, have all its grains of the same diameter. Sand composed of mixed grades contains fewer voids and reduces the quantity of cement required.

Composition of Sands.—It may be well to consider briefly the special qualities required in sands used for concrete. Analyses of sands may be made from three different standpoints. They may be subjected to chemical analyses, and their composition expressed ultimately as a series of oxides. With few exceptions sands are found to consist of 80 to 99 per cent of silica (SiO_2). Alumina (Al_2O_3), iron oxides (FeO and Fe_2O_3), lime (CaO), magnesia (MgO), and the alkalies—soda and potassia (K_2O and Na_2O) are the chief remaining constituents. As an example we may quote the analysis of a sand from Leighton Buzzard, Beds., well known to those interested in concrete:

	Leighton Buzzard Sand (washed). Chemical analysis. Per cent.
SiO_2	99.05
Al_2O_3	0.23
Fe_2O_3	0.14
MgO	0.08
CaO	0.31
Na_2O	None
K_2O	None
Loss on ignition	0.31
	100.12

Such a sand is, of course, exceptionally pure.

Sands may also be analyzed from a mineralogical point of view. The variety and proportions of their constituent minerals are determined by certain special methods, a description of which may be found in modern geological text-books.

Texture of Sands—Mechanical Analysis.—Neither the chemical nor the mineral constitution of sands concerns the concretor very closely, although he uses them on account of their quartz-content. It is only when they contain the clayey decomposition products of the felspars and certain of the heavy minerals that he raises objections. By the mechanical analysis of a sand or aggregate we seek to determine the sizes of the constituent particles or lumps, and the percentage weight of each portion between certain agreed limits of size ("grades"). A definite nomenclature for the smaller grades is very desirable in practice, and the following scheme, based on the metric system, has been found of great service geologically:

Approx. I.M.M. Mesh.				
	G	Greater than 2.0 mm. diam.	Gravel grade [G].	
12-5	VCS	Greater than 1.0 mm. diam. and less than 2.0 mm.	Very coarse sand	Sand grade [S]
20-12	CS	Greater than 0.5 mm. diam. and less than 1.0 mm.	Coarse sand	
50-20	MS	Greater than 0.25 mm. diam. and less than 0.5 mm.	Medium sand	
120-50	FS	Greater than 0.1 mm. diam. and less than 0.25 mm.	Fine sand	
180-120	cs	Greater than 0.05 mm. diam. and less than 0.1 mm.	Superfine sand or coarse silt	Silt grade [s]
....	fs	Graeter than 0.01 mm. diam. and less than 0.05 mm.	Silt	
....	c	Less than 0.01 mm.	Clay or mud grade [c].	

Mechanical analyses of aggregates as well as coarse sands may be effected by screening.

Except for the I.M.M. screens (that is, those conforming to sizes and laid down in specifications by the Institution of Mining and Metallurgy) where the diameter of the square aperture is equal to that of the wire, no uniformity or standardization in sieves exists. Moreover, they are only moderately accurate even when round-holed and made from perforated copper or brass. In any case, sifting is no longer possible for accurate separation when the grades are less than half a millimeter in diameter. Material of this size or less is analyzed by the process known as elutriation, which consists in separating the sediment into grades by means of suitably-controlled currents of air or liquid (usually water). Elutriation by means of wind-currents is utilized industrially in cement manufacture and in the preparation of silica flour, in both cases after the final grinding. For scientific work, air separation is found to be insufficiently accurate and sediments are therefore subjected to mechanical analysis by elutriation, with upward currents of water as the lifting agents.

In view of the fact that the maker of concrete requires coarse sands, free from finer grades, silts and clayey matter, it is unnecessary to deal with elutriation in detail. It is generally agreed that the sand used should not be smaller than 30-mesh, or at the extreme 50-mesh material.

The grain size is undoubtedly the most important factor in concrete-making sands, and it is frequently specified that the sand shall not be less than 30-mesh. The so-called "Standard" sand for cement testing, road metal abrasion, etc., is defined in Britain and the U. S. A. as a natural sand which passes a screen having 20 meshes to the linear inch (0.63 mm. diameter) and is retained on a screen having 30 meshes to the linear inch (0.42 mm. diameter). In the classification adopted above, it corresponds most closely to the coarser part of the medium sand grade. The U. S. standard sand is wrought at Ottawa, Ill., and is a highly rounded sand. The British standard sand is worked at Leighton Buzzard, and is composed of subangular grains (which, however, is not of "standard" size).

The French standard sand is said to come from Leucate, France, and is simple or compound. The simple standard sand must pass a screen having holes 1.5 mm. in diameter (0.06 in.) and be retained on one having holes 1 mm. in diameter (0.04 in.). The compound standard sand is made by preparing a mixture from equal weights of the following grades: (a) 2 mm. to 1.5 mm., (b) 1.5 mm. to 1 mm., (c) 1 mm. to 0.5 mm.

The German standard sand corresponds to the British in size, but the major limit is slightly less (28-mesh). The Austrian standard sand is also of similar size.

It is noteworthy that most of the fairly pure British sands are of rather smaller grade than the standard sand.

Most British sands are subangular in grain. At a few geological horizons, notably the Trias and Permian, rounded grains are abundant. The products obtained by crushing quartz are flaky and splintery, and are not suitable for concrete-making on account of the excessive quantity of voids they yield. Flint is open to the same objection. The hardness of the mineral grains of a sand, and their freedom from cracks, etc., are matters of importance.

The opinion that there is little to choose in the use of sand between subangular or rounded grains is now gaining ground.

In a perfectly graded sand or aggregate composed of uniform spherical grains the percentage of voids varies according to the type of packing. Theoretically, the voids form 47.6 per cent of the bulk when each sphere rests on one other; 39.5 per cent when each sphere rests on two others; and 25.95 per cent when each sphere rests on three others—obviously the method of closest packing. Other arrangements of the spheres also give the last result, which, as the late H. C. Sorby pointed out,* serves to indicate that even when occupying the least volume, the spheres could move about considerably without increasing the proportion of voids. Sands when deposited do not take up an arrangement leading to minimum voids. Shaking or compression, due respectively to earth movement or weighting by accumulated strata above, etc., may reduce their voids. In no case did Sorby succeed in reducing the voids even of fine sand below 34 per cent, the same sand unshaken having had about 47 per cent voids. Sandstones, oolitic limestones and similar rocks may be regarded as natural concretes. It is therefore of interest to recall Sorby's work on the interspaces of such rocks. The cementation of the grains naturally reduces the quantity of voids, which often sink below 20 per cent. In certain cases the proportion falls to 6 per cent and Sheffield Gannister, as a result of infilling by secondary quartz, contains less than 1 per cent.

Washing of Sands, etc.—The effective washing of sands and aggregate to be used for concrete making is a matter of great importance. A perfect solution of the problem cannot yet be said to have been evolved. Some method of "scrubbing" is the only way to clean ballast effectively from adherent clay and loam. On the other hand, the dust produced in the crushing of aggregate can easily be washed away. If the aggregate is required down to 50-mesh, an upward current of water at ordinary temperatures of about 5 ft. per minute (or 1 in. per second) will remove all material smaller than this. If sand is to be added and the aggregate is in consequence required to be not smaller than 20-mesh, a velocity of about 15 ft. per minute will remove the material not required. Many types of sand-washing machines are in operation throughout the country. Fortunately the grade of sand required for concrete making is a size which will wash without difficulty; considerable losses are experienced with fine-grained sands. The objection to most sand washers in use is that the water first washes the dirty sand, and then, before it leaves the apparatus, is filtered again by the clean sand; much of the clayey and vegetable matter thus remains in the sand.

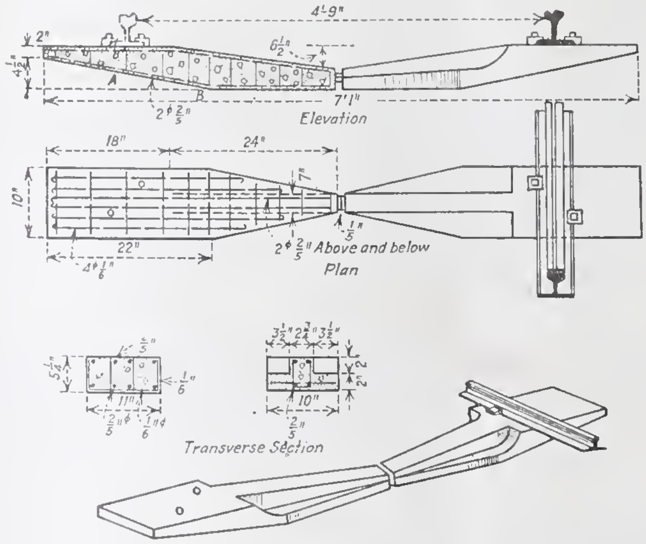
Graphical Representation of Grades.—A considerable amount of work has been done in the graphical expression of the grading of aggregate for concreting—more perhaps than in any other industry. In many cases the object has been the synthetic preparation of mixtures. The principle adopted by the writer in expressing graphically the mechanical analyses of sands is similar to that in use for concrete materials, but there are slight differences in detail which may make it of interest to record the method. The expression of mechanical analyses in the form of curves brings out contrasts and similarities in sands and aggregates more graphically than does any other method. The curves are of course only approximations at the best. Cumulative percentages by weight of material above the grade-size (marked horizontally) are set off vertically as ordinates. The horizontal scale adopted is proportional to the logarithms of the diameters marked, in order to keep the scale representing the various grades within the compass of the page.

Horizontality in any part of the curve means the absence of the material of the grade size corresponding to the distance over which such horizontality extends. Verticality in the graph means a considerable percentage in the grade size corresponding to the position of the vertical portion.

Concrete Railway Ties (Muzak System)

From Concrete and Constructional Engineering, London.

In order to ensure the requisite elasticity which is so essential in railway sleepers, V. Muzak, of Brussels, has devised an arrangement, shown in the accompanying illustrations, in which the ties are in two parts with a central semi-rigid joint, the shape of the ties being different from those usually employed He claims that this arrangement requires a minimum of reinforcement, yet provides a maximum resiliency and a good distribution of the load on the ballast. The inclination of each half of the tie gives it a tendency to slip towards the center and the pressure thus produced is neutralized by the movement of the joint. These sleepers cost 8 francs each at Brussels.



Muzak System of Concrete Railway Tie.

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*See Quart. Journ. Geol. Soc., Vol. 64 (1908), p. 181. See also U. S. Geol. Survey, Water Supply and Irrigation Papers, No. 67 (1902), and 19th Annual Report, Part V. (1899).

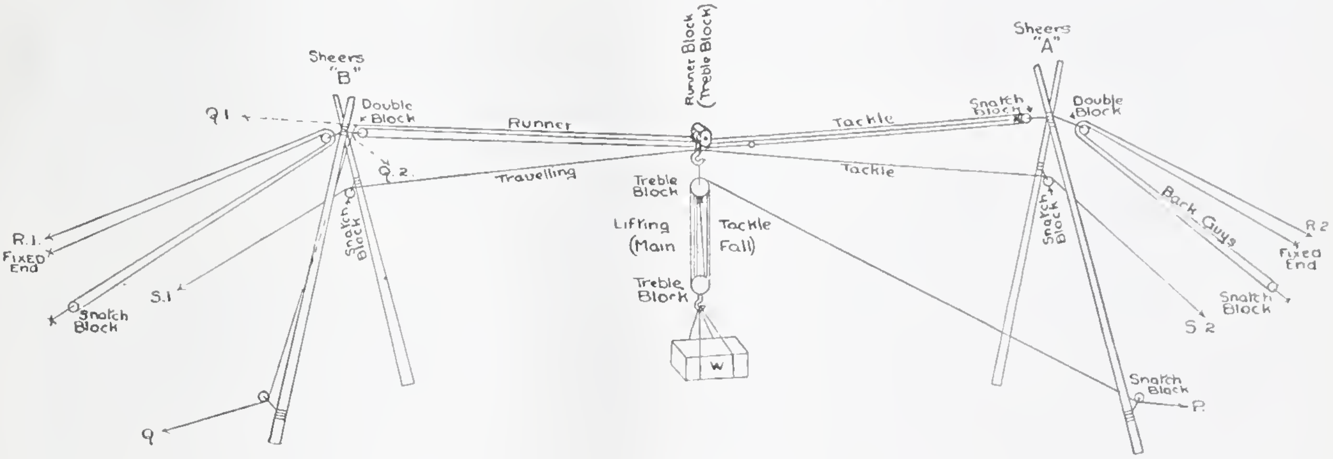
A Field Blondin Ropeway as an Aid to Bridge Erection

By CAPT. I. SIMSON.

From Royal Engineers' Journal, London, August, 1919.

In September and October, 1914, the 8th (Railway) Co., R. E., had to construct two railway bridges in France, and made use of a field Blondin ropeway for launching the girders and dropping the various component parts of the bridge into position.

Such a Blondin ropeway is still of great use for railway construction. It is very quickly erected from material usually available in the field. Its capacity—if constructed of telegraph poles and 3½-in. rope—is probably limited to about 2 tons, but by lifting only one end of girders, etc., at a time this means that about 4-ton loads can be handled and this is generally sufficient. The "reach" of such a ropeway is practically unlimited; it spans the whole of a normal gap, and from the moment it is erected it can be employed continuously for clearing away the débris of the old bridge, running out concrete, etc., for foundations, dropping complete trestles (built on shore) into position if not too heavy, launching the girders, etc. It enables work to proceed, if required, on the whole length of a bridge simultaneously, instead of only on one or at most two spans at a time. Its principles of operation may thus prove of service in all types of field engineering, but its use is of course limited in the case of bridges built on curves.



Field Blondin Ropeway, Showing Arrangement of Tackles.

× Denotes fixed end of rope of any tackle. <— Denotes free end of a tackle by means of which adjustments could be made.

The diagram shows the actual detailed arrangement of the Blondin, as erected in the particular cases referred to. Each pair of sheer legs consisted of two locally acquired telegraph poles 50 ft. to 56 ft. long, butts about 11½ in. diameter and tips 6 in.; the feet of each sheer leg being spaced 13 ft. apart so that a railway truck with material could be run under the legs, and the material picked up direct off the truck by the lifting tackle. The sheers themselves were about 120 ft. apart. The runner, traveling, and lifting tackles, and both back guys consisted of 3½-in. to 4-in. Manilla rope, which was available in coils of 113 fathoms. No blocks with more than 3 sheaves were available at the time. Lashings were of 2-in. rope throughout, while ¾-in. chain was used in addition at each crutch, to couple direct the blocks of the runner tackle and back guys. Side guys of 3½-in. rope were also employed.

The arrangement of blocks shown had the following advantages:

(a) Equal strain in all returns of each back guy and "runner" tackle.

(b) Easy adjustment for the considerable stretch that took place in all back guys and runner tackle. (The ropes were all new and had never been used previously).

(c) By paying out on Q (not under load) the strain on the "runner" tackle was reduced to a minimum for heavy loads; the "runner" tackle being then at a very steep angle instead of approaching the horizontal, and the blocks of the lifting tackle being chock-a-block when the weight was lifted as high as necessary.

The sheer legs had the great advantage of being self-erecting and required no subsidiary derrick poles or tackles to get them up. The legs were placed opposite their footings, both crutches lying away from the gap. One sheers (B) was lashed down to the railway track temporarily; while the crutch of sheers (A) was raised on to a sleeper crib built up on a railway truck—the crutch thus being 12 ft. or so above rail level—and the feet tied back temporarily to the track. By pulling on the runner tackle in the direction Q1 (from the side "B" of the gap), sheers "A" was pulled up and its back guys made fast when "A" was leaning well forward over the gap.

The free end of the runner tackle Q1 was then run over the second pulley of the double block at the crutch of sheers "B," and, by pulling in the direction Q2, sheers "B" was raised. When also leaning well forward the free end (R1) of the back guy for "B" was made fast, and the free end (Q2) of the runner tackle run through the snatch block (at foot of sheers "B"), in its final direction Q, in which it was made fast. The legs were adjusted for verticality by taking in or paying out on R1 and R2. The runner tackle was adjusted to suit by paying out or taking in Q. The operation of lowering was carried out by practically reversing the above process.

The sheer legs "A"—on the side of the gap to which material can be brought by rail or road—should be situated as near the edge of the gap as possible consistent with picking up the loads directly (off a railway truck or lorry run between the legs); and the running end P) of the main fall should be run off on this side of the gap. Sheers "B" should be situated as far from the edge of the gap as length of cordage will allow. The object of this is to get the far end of the bridge near the center of the Blondin span. All loads than run down the runner tackle, till at the center of the Blondin span they are at their lowest point. If they have to go further than this, the loads must then be pulled up the runner by means of S1. Steel cable for the runner tackle would undoubtedly prove a great improvement for such a Blondin

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Early Concrete Roads in Great Britain

In an address, abstracted in The Surveyor of Aug. 29, 1919, R. L. Bendall states that what was probably the first piece of actual concrete road surface in Great Britain was constructed in Scotland in 1865, and was the approach road to the Inverness Goods Station.

Gillespie-crescent, Edinburgh, was laid 33 years ago with 10 in. of mass concrete; its surface is good now, though defaced with patches where mains and house services have been repaired. This crescent has ordinary suburban traffic.

Gandy St., Exeter, is narrow, its surface is concrete with stone channels. It is not broken, and is quite good, although its age is about 30 years. The camber of this street is far from ideal, but no doubt was the camber then in vogue for water-bound roads.

Twenty-one years ago a firm of contractors in Worcester laid down 3 in. thick of concrete as a surface to the yard of a skin warehouse in Lowesmore, Worcester. This was well constructed, for, although there is a constant stream of horse vehicles in and out of the yard, its surface is good and has worn during a period of 21 years not ¼ in.

In Dundee, near the cattle market, 30 years ago a concrete road was laid; the traffic over this is certainly not heavy, but the surface is good today.

Some Notes on English Highway Construction

By H. T. CHAPMAN,
County Surveyor, Kent.

From The Surveyor, London, July 11, 1919.

Those of us who have endeavored to keep things going at home during the war have learnt not a few useful lessons. The great object-lesson to the writer has been the futility and waste of money in endeavoring to repair and maintain roads for excessive mechanically-propelled traffic in the former method of piling on broken rock and macadam to be shattered, pulverized, and subsequently removed in the form of mud and dust. Again, most, if not all, surveyors have been agreeably surprised at the amount of additional traffic carried without undue damage to certain sections of their roads which were constructed and surfaced in an up-to-date manner, and also by the fact that they managed to keep going with judicious repairs many lengths that were moderately foundationed and surfaced.

Foundations.—The writer's experience is that vast sums have at times been wasted—or may we say buried?—by improper and inefficient methods of dealing with our roads, and he contends that much more money has still to be buried, but in this case well invested, in the provision of adequate and suitable foundations to receive whatever type of surfacing is to be adopted and also in properly dealing with subsoil and surface water drainage.

Imported and costly materials need not in all cases be used, either in the foundations, base coats, or sub-crusts and surfacings, but so-called inferior and local materials, and even misnamed waste products, can be utilized to equal, if not better, advantage if properly treated and applied. Just as tar, pitch, and bitumen treatment has revolutionized the road surfacings during the past ten or twelve years, so the writer ventures to assert will the foundations and sub-crusts be treated and improved in the near future, and surveyors will recognize that homogeneous and, as near as may be, voidless underbeds treated either with cement, tar, pitch, or bitumen binders are absolutely necessary, and must be provided for all roads carrying any appreciable amount of traffic. Some slight resiliency or "give" in the surfacing material is desirable for comfortable traveling, and when this is provided it is also necessary to have the same in the underbed or sub-crust to prevent undue movement by traffic of the surfacing material.

Very many miles of our existing roads contain sufficient road metal which has been piled on unsuitable foundations or sub-soils during former years, and if several inches in the thickness is scarified, screened, and mixed with pitch and tar, it can be utilized to form quite suitable bases or sub-crusts for surfacing with tar-macadam or bitumen carpeting in order to carry considerable traffic. In some cases the "carpeting" need not be laid forthwith on this bituminously mixed material, which may well be utilized for carrying the traffic until such times as the improved surfacing can be proceeded with. In 1911, when the Sidcup sections were laid and the existing water-bound granite was removed for the purpose, the scarified material was relaid and grouted with a pitch, tar and sand mixture on another section of the London-Folkestone main road, about 7 miles distant, and this is still in first-rate condition.

Lateral Support.—It is also imperative that adequate lateral support in the way of curbs or suitable irremovable haunches must be provided for all roads carrying heavy traffic in order to prevent movement and spread in the surface and sub-crust, at the same time as the reconstruction of the carriageways is in hand.

Tar-Macadam.—The advantages of tar-macadam over the ordinary so-called water-bound macadam are too well known and apparent to enlarge upon; but the writer would impress upon all the necessity of slight patching and annual surface tarring to protect and preserve the surface if the best results are to be obtained. He has frequently laid what may be termed a second-class quality tar-macadam, such as tarred Kent ragstone underbed, and topped this with a wearing surface of tarred slag macadam, and, as, far as he can see, the result has been equal to that which would have obtained had the whole thickness consisted of the latter material, and some saving in cost has been effected.

Unsatisfactory results and excessive waviness are sometimes obtained in consequence of surveyors endeavoring to consolidate too great a thickness of tar-macadam by rolling in one operation, and also in not topping and completing the surfacing before much traffic passes over the new work in hand.

In former days many of the roads had too much camber, and became "hogbacked" owing to constant middling or centering; subsequently many went to the opposite extreme in making the roads too flat. It is found in practice that tar-macadam flattens or further consolidates under the traffic for some time after the rolling is completed, and this should be taken into account when arranging the crossfall of the new surfacing. Generally speaking, a crossfall of ¼ in. to a foot is ample.

The question is frequently asked as to the steepest gradient to which tar-macadam may be laid for safety to horses. The writer has laid it on gradients up to and even exceeding 10 per cent, but he makes a practice in such cases of omitting the fine, tarred material for sealing the surface and also of scattering the 1½-in. topping material generously with ¼-in. grit or chippings before finally consolidating the material. This gives a somewhat rougher surface and better foothold for horses. He does not favor the practice of laying a portion of the width of carriageways in different types of surfacing, as it is almost impossible to maintain them satisfactorily under these conditions. Most surveyors have experienced the difficulty of keeping up the margins of a macadam road adjoining the paving in tramway tracks. Horses and their drivers very rapidly become accustomed to smooth and better-class road surfacings, which manifestly dry much quicker, and the advantages obtained very greatly outweigh the slight inconvenience of slipperiness under certain climatic conditions which affect all classes of roads to a greater or lesser degree.

Pitch Grouting.—Good results have been attained in many parts of the kingdom in pitch and tar grouting of roads, but one disadvantage of this work is chiefly due to the fact that dry weather is practically a sine qua non for these operations. There is also some difficulty in obtaining even distribution of the grout and filling all the voids, especially when the aggregate is laid to a fair thickness. Some non-successes have certainly been due to the use of too large an aggregate and not sufficiently wedging or interlocking it with chippings.

A considerable mileage of roads in Kent have been surfaced in pitch-grouted macadam, and some after 7 or 8 years' life are still in good condition. The matrix consisted of softened and suitably fluxed pitch mixed in the proportion of 5 parts pitch to 6 of sand, and heated to not exceeding 340° F., when the grout would readily flow at about 300° F. if stirred constantly until used. It has been necessary to patch with chippings or grit and tar any holes or frayed patches, and surface dress with tar and chippings the whole area annually. The pitch-grouted areas make quite a good base for subsequent carpeting.

Bitumen Carpeting.—Provided the necessary bitumen—which word is generally taken to include natural asphalt and petroleum residuals, also the fluxing oil—can be obtained at reasonable prices, and the requisite plant for heating and mixing it with suitably graded sand or selected and properly graded destructor clinker is available, there is no doubt that the carpeting or surfacing with this material on a suitable base coat will be extensively adopted, and it is a most acceptable and economical method of dealing with our roads. It will also, generally speaking, meet the requirements of all traffic to be expected, with perhaps few exceptions.

The work is done in two operations, and the base coat, which should not be less than 3 in. in thickness, may consist of any local stone, flint, scarified material or clinker mixed with pitch, tar or bitumen laid hot in order to form as nearly as may be a voidless concrete. The greatest care is necessary in preparing the carpeting material, for which the aggregate of sand, grit or selected crushed clinker must be graded between a 200 and ¼-in. mesh in order to provide as near as may be a voidless and cohesive material when mixed and laid at a temperature of 300° to 500° F. While the writer is somewhat diffident about giving details as to exact proportions of the various ingredients as so much depends upon the grading of the aggregates, having regard to their specific gravity, also the fluxing of the bitumen, he would say that the proportion of the latter should vary according to circumstances from 13 to 15 per cent. An area of 20,711 sq. yd. of two-coat work which was laid on the London-Dover main road between Sittingbourne and Faversham from May to October, 1914, is still in practically the same condition as when completed, and as far as can be seen at present is good for another 5 years. The length of road is not curbed, which is admittedly a disadvantage, but the war was on at the time when the work was in hand. Ballast boards were, however, put in at weak points to support the sides.

The base coat, ¾ in. in thickness, was composed of crushed shingle and flint 1½ in. to ½ in. gauge coated with pitch and tar mixture in the proportions of 8 of soft pitch to 3 of tar to Road Board specifications. The composition of the carpeting mixture, laid 1½ in. thick, was: British Portland Cement Co.'s grit, 31 per cent; Aylesford sand, 56 per cent; and Mexphalt 13 per cent. The binder necessitated the use of 1 ton of Mexphalt and 20 gal. of fluxing oil. All these ingredients were heated to 350° F., and mixed in a Koehring hot mixer. Primary consolidation was carried out by cross rolling with a small water-ballast roller and final consolidation by a 10-ton steam roller.

The weather was wet during a portion of the time the work was in hand, but this does not appear to have been detrimental. The cost of the whole work came out at 5s. 1d. ($1.22) per sq. yd., the base coat 2s. 6d. (60 ct.) and the carpeting 2s. 7d. (62 ct.), but the prices of the materials were practically prewar rates, the Mexphalt at £5 13s. 6d. ($27.50) per ton and the fluxing oil 4½d. (9 ct.) per gallon.

The census of traffic taken in February, 1914, shows that 3,744 tons of traffic passed over the road in seven days, and this included motor omnibuses, motor lorries with steel and rubber tires, traction engines, etc. During the war period the heavy and destructive type of traffic was considerably in excess of that during the period recorded, and no undue damage has been caused.

Separation of Storm Water and Sewage

By EDWARD B. SAVAGE,
Engineer in Charge of Sewers, Birmingham, England.

From the Proceedings Institute of Municipal and County Engineers.

Most engineers have their own ideas as to the best design of an overflow chamber, but, as in many other details of sewerage, finality has by no means been attained. Taking as an instance a case where separation is effected by means of the usually short weir, having its crest at such a level that discharge commences to take place when the usual rate of dilution, say 6 to 1, is reached. Provided that the volume of sewage causing the weir to operate remains constant, the size of the outgoing sewer can be correctly adjusted to deal with this volume. Normally, however, the rainfall either lessens or increases in intensity, so that in the latter case, instead of a thin film of water passing over the weir, a considerable rise in the flow takes place, with the result that the sewer below has to carry a larger volume than that due to a 6 to 1 dilution—in other words, it is necessary either to provide an unnecessarily large sewer or to throttle the outlet. The amount of contraction to be given in such a case, however, is only determinable under the conditions existing at one period of discharge, so that, apart from the objection to back-pounding of the flow above, it does not effectively serve the purpose of equalizing the flow in the outgoing sewer.

For many years past this question has been carefully studied in Birmingham, and various devices have been adopted with a view of eliminating the head at the outlet end of the weir. By means of one of these the incoming diluted sewage is deflected into the river by a series of curved reinforced concrete vanes placed at different levels so that in action each vane may be said to "slice off" a certain depth of the flow so reducing the head at the outlet end. Although perhaps as efficient as any form of separating weir yet designed, the author recognizes that there still exists a certain head at the outlet, which would vary according to the length of the weir and the volume brought down. Moreover, there is still a certain back-pounding due to the contracted orifices under the vanes, and also the head caused by the artificial deflection of the flow. In the light of past experience it appears to amount to this—that any obstruction whatsoever is a disadvantage, and that the simple form of weir in which the stream lines accommodate themselves to their proper curves without artificial assistance is still the best. The all-important point appears to be to have a much longer weir than is usually adopted, and by this means only to equalize the flow.

Stream Flow and Percolation Water

By SAMUEL HALL,
Assistant Water Engineer, Belfast.

From the Journal of the Institution of Water Engineers of Great Britain.

The author, many years ago, commenced investigations of the conditions which govern and control the ever-varying flow of streams and rivers, conceiving that, even were no definite laws established, he might gain a better knowledge of the subject, and information of practical value. The author considers that the agreement between data and facts from widely different sources is such as to fully warrant the statements made in this paper. The subject is treated broadly, and in order to make it clearer many well-known conclusions are repeated.

Figure 1 is a flow curve showing inconstant rates of discharge for a period of 24 days, and some features characteristic of probably all stream flow curves, the most noticeable being the "peaks" following rainfall, showing immediate increase of flow attributable to surface run-off. Another feature is the slowly falling parts obtaining in rainless periods, when the flow is that of percolation discharge alone. The curve shown represents the flow from a mountain catchment of between 2,000 and 3,000 acres in extent, and is taken from automatically recorded diagrams of depth of water over a weir. It shows quick "run-off" and very marked, yet not exceptional, variations of flow.

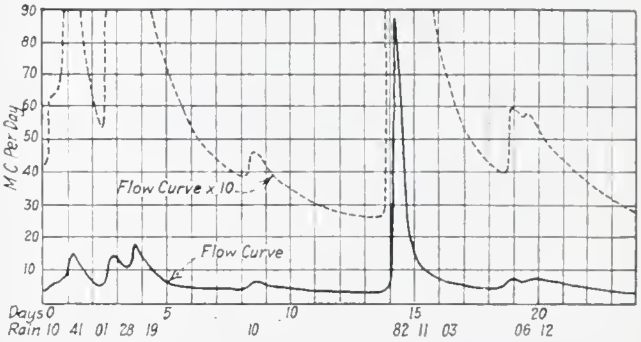


Fig. 1—Stream Flow Curve.

Comparison of Peaks of a Stream.—Before comparing "peaks" of different streams, it will be interesting to compare those of one stream. They are greatest in proportion to rainfall when the surface soil is moist, always large in winter and after wet weather gradually smaller as summer advances, and smallest near the end of a long period of drought, when they contrast greatly with those of other periods. The rate of rise to a peak, when other conditions are the same, is a rough measure of rainfall intensity, which affects the height of the peak and flood rates. The falling part of the peak curve is generally slightly "slower" than the rising part, and becomes still slower as it descends. It indicates the rate of surface drainage after rain has ceased, and appears to be of some approximately regular form, but is, of course, modified by the amount of percolation discharge. The gently falling and lowest parts of the curve due to percolation discharge are generally gradually higher from the autumn and lower from spring to the end of summer, being lowest at the end of a long drought. One characteristic of these parts is the steady fall of the curve, showing not only that the rate of flow decreases, but that its rate of decrease also diminishes; in other words, the curve gets flatter from day to day throughout a rainless period. Towards the end of a drought the diminution is so small that the curve might appear to have become a horizontal line, yet examination of a greater length of curve will suffice to show such a conclusion is wrong; but it appears probable that a slowly diminishing flow might be continued during perhaps a year of further absolute drought. Some streams in these islands occasionally run dry, yet the larger streams and rivers have substantial discharges in droughts which are but of short duration compared with those which occur in some other countries. Another feature to which attention must be drawn is that the position of these parts of the curve is raised after every peak occurs. To make this clear, let us imagine a prolongation of the curve obtaining before the peak, on the line it would probably have taken had the rainfall not occurred. The produced curve would, apparently in every case, lie some distance below that which actually obtains after the peak, and the amount of difference between the produced and actual curves appears to be roughly proportionate to the extent of the peak. It seems to be clear that not only has there been a large immediate yield as shown by a peak, but that the stream has gained in "staying power." The conclusion drawn is that new supplies of percolation water have increased the amount in store, with the result of increased discharge. The effect of frost is, in general, precisely the same as that of absence of rain. Frost does not affect the percolation discharge, except perhaps where such occurs as small surface springs, but it holds up surface "run-off." Snow, of course, does not affect flow until thawing takes place.

Conditions Affecting Shape of Flow Curves.—In comparing curves of different streams it may be seen that the slope of the ground is a factor which affects the rates of rise and fall, and also the size of the "peaks," no doubt because less slope and slower "run-off" allows surface water to remain for a longer period under percolation influences. The length and slope of the stream courses are factors influencing chiefly the shape of the peaks, because after water has supplemented the flow in the upper reaches of the stream some time elapses before the effect is recorded at the gauging point. This time, roughly determinable, is a matter of hours for small streams, but of days for large rivers. Every stream course has a slight temporary storage effect, which is increased where the banks are permeable and extensive.

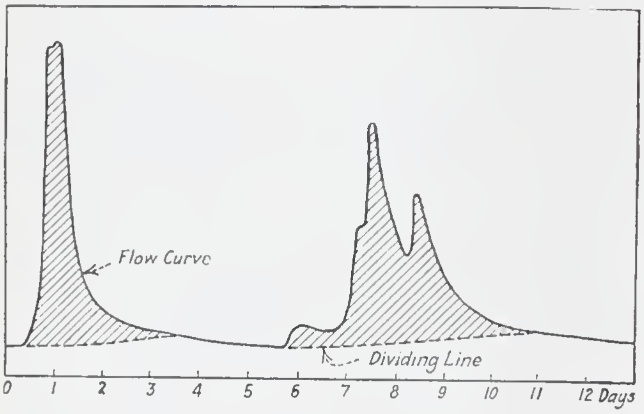


Fig. 2—Estimate of Surface Run Off.

In order to form a rough idea of the extent to which the nature of the drainage area affects the peaks, we may assume the case of a river fed by a number of streams of simliar drainage areas at various points. The effects of spates on each stream would be recorded at times, varying roughly according to the distance of the points of confluence from the gauging station. Tracing the flow curve of one stream, and altering the time for each so that if superimposed the peaks would show one after the other, the sum of these stream flow curves representing the total flow of the river, would obviously show less rates of rise and fall, and a less maximum rate in proportion to the total drainage area. Though other factors might modify the curve, the logical conclusion is that increase of size means flatter peaks and smaller maximum or flood rates in proportion to the area, while the converse holds for smaller areas.

"Dry weather flow" is used by various engineers to mean either minimum known flow, or that for one year (average), or occasionally a supposed irreducible and constant rate which would obtain under any exceptionally adverse conditions. As a term so variously interpreted cannot lead to anything but confusion, what is meant should be expressed in other words. The minimum rate of flow is seldom the same in any different years, and any particular minimum only holds good till a lower one is recorded.

The sources of supply due to precipitation can be classed as: (1) Surface run-off; and (2) percolation discharge. The chief source of deficit between rainfall on the area and resultant flow is evaporation loss. Another source of deficit is the loss of percolation water, which is inevitable, though it might be small in amount; but, on the other hand, this loss might be more than compensated for by gains of percolation water from sources outside the topographical drainage area.

Factors Affecting Surface Run-off.—That part of the rainfall which falls on the water surfaces as a "direct contribution" to the stream is measurable by the product of rainfall and water area. It causes the first upward turn of the curve at a peak; normally small in amount, it becomes a greater proportion of peaks towards the end of a period of drought, and might at such times be the only benefit from rainfall.

Some of the factors affecting surface run-off have been already mentioned. Absorption and percolation are factors which are probably not of equal effect over the whole of the drainage area, and also vary according to weather conditions. Surface run-off will occur when and where the rate of rainfall exceeds the rate of absorption until the surface soil is saturated; then it depends upon the difference between rates of rainfall and percolation.

The proportion of rainfall yielded as surface run-off is high when the ground remains frozen, and is generally very small in summer, sometimes very large, however, after the ground has been "baked," but whether this is actually due to the "baked" condition of the soil or to greater intensity of rainfall, such as obtains in thunder showers, has not been satisfactorily determined. The author has observed in ground over clay subsoil that extensive and frequent cracks develop during droughts, and it is questionable whether such cracks, at times 2 in. in width and more than a foot in depth, would not counter-balance the effect of baking the ground.

While the ground is under the effect of recent rains, a subsequent rainfall produces a greater result in the amount of run-off. A few hours after rainfall has ceased it would be very difficult to detect, on the gathering ground, any indication of surface run-off (except where flooding has occurred), though it is quite noticeable during heavy rains from the newly formed streamlets appearing in ill-formed and miniature valleys in the drainage area.

In estimating the time at which it becomes nil or negligible, the fact of thin films of water being almost unnoticeable should be taken into account, and the author's estimate of the time which might elapse before the surface water has reached a stream course is given as seldom more than 48 hours, but variable according to the amount of rainfall, percolation rate, and surface slope. On this assumption dividing lines have been inserted in the flow curve in Fig. 2, to show an estimate of the increase of flow due to surface run-off; this is shown by the cross-hatched portions. By treating all the peaks in the same manner, an estimate of the yearly total of surface run-off can be made. The amount of flow, as shown by the low-lying parts of the curve, and up to the dividing line or lines is likewise an estimate of the percolation discharge. Where rainfalls succeed one another, the guide to the insertion of the dividing lines should be the estimate of percolation discharge, which has but a slowly increasing rate, and the dividing lines must obviously commence at a part of the curve which indicates percolation discharge alone. In the case of large rivers, allowance for the time taken in flowing down the river will be necessary, but percolation discharge will be the best guide for estimating purposes. It is not, of course, possible to determine accurately what proportion is due to the two intermediate sources of supply, but it will be noted from Fig. 2 that were the time of 48 hours altered to 36 or 60, it would not affect the estimate very materially.

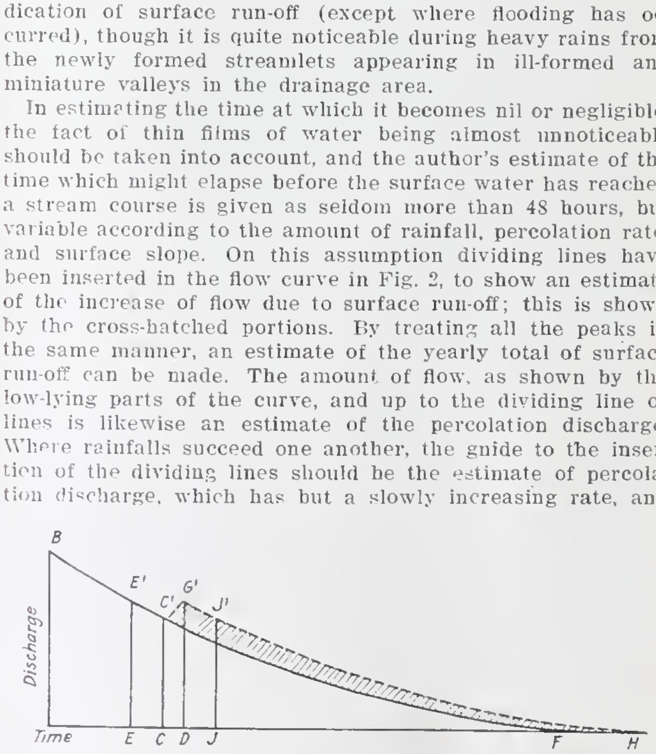


Fig. 3—Tank Discharge Curve.

The area from which surface run-off occurs is obviously defined by the natural water partings, but it must be noted that this area is not necessarily identical with the percolation drainage area.

Conditions Affecting Percolation Discharge.—Of percolation discharge there is visible and irrefutable evidence in the existence of springs discharging percolation water at the surface of the ground. There are also subaqueous springs discharging into the beds of streams, rivers and the ocean less apparent and likely to escape notice. There are doubtless similar discharges of percolation water which, from finding easy passage through alluvial deposits to open water, are perhaps outside the possibility of detection. Considering that almost all rocks are fissured, and that the beds and banks of streams are, as a general rule, extensive alluvial deposits, it is most probable that a surface discharge occurs as an exception rather than a rule. There is no better evidence of the temporary storage of considerable volumes of percolation water than stream flow when the surface soil is parched, for at such a time the whole of the flow is obviously from such sources. So far as stream flow is concerned there is no need to make any distinction between visible spring flow and other percolation discharge, as the laws which apply to one apply with equal force to the other, and to percolation discharge as a whole.

The geological conditions of the drainage area affect percolation storage and discharge, yet in the author's opinion physical conditions have often greater influence. For example, the same bed of grit may be in one locality very much fissured, and in another considerably less so, and such differences mean like differences in storage capacity. Limestone, granite, other compact rocks, and also alluvial deposits, likewise differ in storage capacity in fissures and interstices. The rate of discharge also depends probably more on physical than geological conditions, and the greater width of an outlet for percolation water might be merely accidental. The volumes of water which can be absorbed by compact rocks after they have been heated to dryness is very considerable; yet this should not be taken into account, as all the deep subsoil rocks are, and remain, moist while in situ, and the amount they can retain, despite the force of gravity, is most probably constant. For these reasons the author strongly inclines to the belief that it is the fissures, and not the compact rock, which yields the percolation discharge. There will doubtless be cases where the water percolates through compact rock; but where fissures occur, they provide much quicker drainage for the bulk of percolation water.

Percolation Discharge and Hydraulic Laws.—It is not proposed to consider the subject from a geological point of view, but to consider how far percolation discharge is subject to known hydraulic laws, and in order to do that it is necessary to consider the physical conditions which affect storage and discharge. Percolation water, having passed through surface soil into permeable strata, trickles downwards through interstices and fissures until its downward progress is stopped by impermeable strata, or until it reaches an existing water surface. Its course afterwards, in either case, is most probably like that of water in open channels, to which fissures and large interstices in the strata are a rough parallel. Each fissure or miniature channel has its rate of discharge and a hydraulic gradient inseparably related to the discharge rate. The hydraulic gradient is, of course, the water surface. The surface of percolation water in a network of fissures and interstices, assumed continuous through intervening rock, has been termed the surface of saturation, but is more generally called sub-soil water level. It is really a network of hydraulic gradients, and for any particular position there is a related flow, or rate of discharge. Its slope depends partly on the size and extent of the fissures, which, being usually of small size, will have steeper gradients than those which we usually associate with open channels. The surface of saturation is not level; it bears no relation to the surface of the ground, but inclines towards the outlets for percolation water, and it coincides with free water surfaces. Its position is not fixed, but is slowly altered by discharge and supply; and should supply disturb the hydraulic gradients throughout the surface of saturation, there is a natural tendency to settlement to some position which corresponds throughout with a particular discharge rate.

The conclusions are that where part of the rainfall can percolate to the deeper subsoil, a surface of saturation is formed in the fissure and interstices of the rocks, and that there is a rate of percolation discharge corresponding to each position of the surface of saturation, and such conditions will generally obtain. Where clay immediately underlies the surface soil, discharge conditions are perhaps slightly different, but the author has not had an opportunity of investigating such a case.

Determination of Quantity of Percolation Water.—The conditions of storage of percolation water may not always be the same as those mentioned, for it is quite possible there are what might be termed natural subsoil, but leaking storage reservoirs, the discharge from which might be considered as from a reservoir outlet pipe. In such a case hydraulic laws would apply, and the discharge would have its related "head" and its hydraulic gradient. The author has evidence in two cases of excavations which pointed to the existence of leaking subsoil storage reservoirs. In one of these cases the volume of water was large, and the annual variation of water level small, sufficient to show that it leakage did occur it could have been continued for at least a year of absolute drought.

In considering how the available quantity of percolation water might be approximately determined from percolation discharge, it will materially assist if we first consider conditions affecting the discharge from a tank. The discharge rate or flow curve from a pipe outlet from an irregularly shaped tank would be of some such form as shown by the firm line EF in Fig. 3, the rate of discharge at any time being represented by an ordinate of the diagram at that time; thus EE represents the rate of discharge at the time E. Having the whole diagram, the total discharge is measureable; the total discharge represents the "storage capacity" of the tank, which is thus determined by means of the flow curve alone. Let us call this curve (EF) the basic curve, and note that any rate of discharge denotes a related position of the water level in the tank, and some corresponding amount of storage. It is quite obvious that if the tank were again filled, the basic curve would be reproduced; and if the rate of discharge at a given time be ascertained, the subsequent rates of flow, or the total available flow, can be foretold from the basic curve, no actual observations of the water levels in the tank being necessary. When a fresh supply of water is poured into the tank, it results in a corresponding alteration in the flow curve, which repeats some part of the basic curve after the supply is stopped, and by means of the basic curve the amount of supply can be determined.

This case is illustrated by the dotted line in Fig. 3, which shows the effect of a fresh supply. After the supply has been stopped, the flow curve GH is a repetition of a part of the basic curve. The rate DG being the same as EE at some point on the basic curve, the curve GH is the same as the curve EF. It is obvious that the amount of the fresh supply has caused the increase of flow shown by the shaded portion of the diagram, and the difference between the total discharges as shown by the curves CGH and CF obviously shows the total amount of the fresh supply. The latter is also measurable in another way; the ordinates EE and DG are equal, and show that the quantity of water in the tank at the times E and D were the same; hence the total discharge between the times E and D as shown by the curve ECG was the net gain, or the amount of fresh supply. Similarly, by locating the time J when the ordinate JJ is equal to CC, the total discharge between the times C and J, shown by the curve CGJ, is also equal to the fresh supply. The last mentioned is the method which appears most convenient for ascertaining the amount of gains accruing from rainfalls.

It must be borne in mind that it is a short method of measuring total gain, which, as shown by the shaded portion in Fig. 3, causes an increase of flow over a considerably longer period than that denoted by the time CJ. The aggregate percolation discharge from a drainage area is really a number of discharges from different ill-defined and overlapping areas, and may be likened to that from a series of tanks having various rates of discharge and various rates of supply, making it doubtful whether the principles would hold good; yet the average rate of supply to each tank governs the rates of discharge to a considerable extent; thus, when supplies are small low discharges prevail, and the converse of this also holds good.

The supply of percolation storage is "available rainfall," the governing influence of which is best illustrated by the fact that streams and rivers throughout the country show lowest flows at about the same times. It is now proposed to apply the above-mentioned principles, which are based upon well-known hydraulic laws, to percolation discharge, which is believed or assumed to be subject to the same laws, and should tests indicate agreement, it might reasonably be presumed that the assumption is correct.

Basic Curve of Percolation Discharge.—Let us now suppose that after a period of considerable percolation the natural storage of percolation water is as great as it can be, that the stored water receives no further supply, but is exhausted by discharge. The flow curve obtained during this period, hereafter called the "basic curve of percolation discharge," would be a parallel to the basic curve of the hypothetical tank discharge; and whenever similar conditions obtain, some parts of the basic curve should be reproduced between times of fresh supplies. Let us now test the actual stream flow curve to see whether or not it does behave in this manner; for if it does, we might, from these reproduced parts, construct a considerable length of the basic curve. The method of testing is as follows: Reproduce on a diagram the flow curve shown during an absolute drought in which the lowest flow is measured, as AB in Fig. 4. Reproduce a second drought flow curve in which the second lowest flow is measured, as CD, so that the ordinate showing the second lowest rate coincides with the ordinate of the first curve showing the same rate. Then, if the principles apply, a length of the second curve will coincide with a length of the first, and the coinciding portions show a length of the basic curve. Similarly, other drought or rainless period lengths of the stream flow curve can be reproduced until the greatest available length of basic curve is obtained. It is recommended that a tracing of the basic curve be then applied throughout the stream flow to test whether the flow curve in all rainless periods reproduces a part of it. The author tested in this manner the basic curve as shown by EF in Fig. 4, and found that the discrepancies were so slight that they may have been due to variations of evaporation from the stream surface. For accuracy, fine readings are necessary, particularly where the flow curve is almost flat, but in two cases the author obtained basic curves where only rough daily gaugings were given, and these showed agreement with actual flow in rainless periods as nearly as it was possible to ascertain. The stepped curve of daily gaugings was replaced by one passing through the middle points of the horizontal portions. The basic curve as shown by EF in Fig. 4 agreed with the stream flow curve from three to five days after rainfall had ceased; towards the end of this period the difference between the two was slight, but such as to shorten the times at which the basic curve was applicable; and this period was in another case apparently from four to as much as ten days, and in each case varied as the yield from rainfall was smaller or larger.

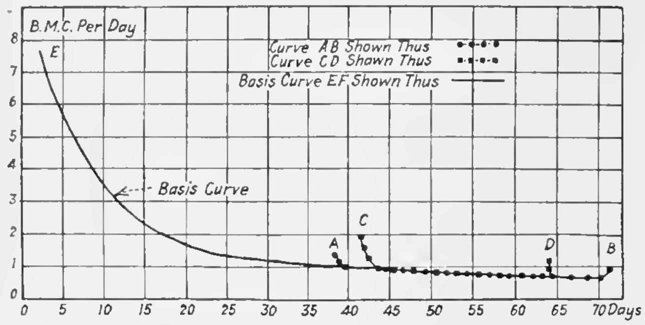


Fig. 4—Basic Curve of Percolation Discharge.

It will be obvious that the basic curve of percolation discharge is not capable of application at times when there is both surface run-off and percolation discharge, and that its use would be strictly limited to the times at which the flow curve of the stream had assumed the basic curve form, and it is important that this should be noted. When the former has assumed agreement with the latter for even a short distance, the basic curve can be used, in precisely the same manner as that obtained from the hypothetical tank discharge, to foretell subsequent rates of flow which would occur in the absence of fresh supplies to the limit of minimum flow previously measured, and to state the time at which that limit would be shown; also to determine the volume of percolation water available in the meantime. Where times of application permit, the fresh supplies form periods of rainfall, i. e., the available percolation supplies, and occasionally that due to a particular rainfall, also the difference between the respective amounts of available percolation water in store at different times, can be determined. It may be noted that the length of the basic curve was determined only to certain limits, but this fact does not prevent its use. An estimate of its continuation could be made for the purpose of determining probable minimum flow under worse conditions, but otherwise would not be necessary.

When a tracing of the basic curve is applied to a flow curve at a time before a peak, to show how the latter would have continued in the absence of rain, the difference between the two curves shows the increase of flow which the rain has caused. So much of the increase as is due to increased percolation discharge would be of similar form to the shaded portion of Fig. 3. The maximum benefit from this source is shown to occur a short time after rainfall, but the benefit continues for a very long period at a slowly decreasing rate. As a corollary, it might be expected that the total percolation discharge at any time depends upon the amount of percolation which has obtained during many preceding months, and the effect of percolation during a particular month is reflected most largely in the next month, and to a less and less extent in each succeeding month. Examinations of many flow curves have confirmed this fact.

Let us now assume that before and after a particular rainfall the stream flow curve has assumed the basic curve form, and at particular times before and after the peak the rate of 2,000,000 gal. per day is recorded; the gain is the total discharge between those two times, because the available amount of percolation water, as indicated by the basic curve, was the same at both times; thus the benefit accruing from a particular rainfall is measured. In this case, should the stream flow curve assume the basic curve form, but not continue so far as to show the rate of 2,000,000 gal., but only, say 4,000,000 gal. per day, the basic curve can be applied to the flow curve to continue the latter to the time at which the rate of 2,000,000 gal. per day is shown. Then the total discharge, as shown by the flow curve and its continuation, between the two times represents the amount of gain.

This case is illustrated by Fig. 5, which shows an inserted curve EF, which is a reproduction of a part of the basic curve. The time J is fixed by the rate IJ, which is the same as GH. A, B and C show the total gain due to the particular rainfall. A is the estimated surface run-off, whilst B and C show the gain of percolation water. The curve at G must be of basic form, otherwise the principles are not applicable to this case. It was not necessary to draw the portion C, as its equivalent was measurable between ordinates of the basic curve, in this case representing 4,000,000 and 2,000,000 gal. per day, but it suffices to illustrate plainly how much more percolation water was in store at the time K than at the time H, and shows what might be called the "correction" for percolation storage. It is suggested that this correction be made in figures representing calculated evaporation loss; and as in cases where these figures are taken over a period the correction might be equivalent to 2 in. of rainfall, it is plan that uncorrected figures may be inaccurate. Were the basic curve only approximately obtained, it would be of some value for making this correction. The basic curve serves to illustrate the fact that over a period when percolation supply becomes reduced, "depletion" of percolation storage takes place, and this will continue until the average rate of supply and the average discharge are roughly balanced, though neither is actually constant. Conversely, when percolation supply over a period becomes increased, the "filling up" of percolation storage takes place before supply and discharge roughly balance. From another point of view, it might be seen that the average rate of discharge does not immediately change to equal an average rate of supply, but the difference goes to, or

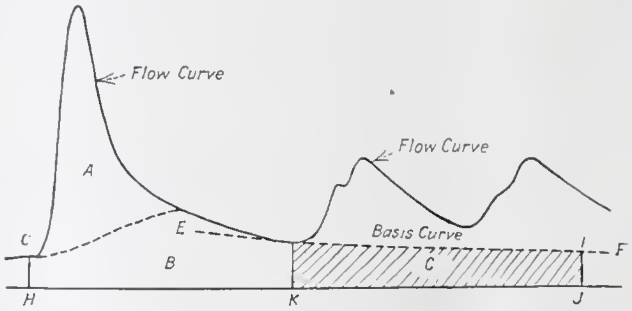


Fig. 5—Flow and Basic Curves.

is taken from storage, until the surface of saturation is at such a level that average supply and discharge are about balanced; thus a year's minimum can only occur after a period of small supplies, and a year's maximum only after a period of large supplies.

It occurred to the author originally that if one could determine the available percolation water stored in a drainage area at the end of a winter period, there would be something of value in estimating the amount of artificial storage required to maintain a constant supply, because with a greater amount of natural storage less artificial storage would apparently be necessary. The available percolation storage can be ascertained with the assistance of a basic curve, no doubt in many cases within near limits; yet the author thinks this figure would be of doubtful value, for it is obvious that before percolation discharge can become equal to its average rate, supplies from subsequent rainfall must first replenish the depleted percolation storage according to the amount which has been temporarily available from that source. And for the same reason it is doubtful whether the figure of minimum rate of flow is of much value where a large proportion of the mean flow is required for a constant supply.

The author suggests another use for the basic curve in which it might be of more value. As evaporation during the winter is small and the gains from rainfall should nearly equal the rainfall, the former is the discharge, plus or minus the difference in percolation storage at the beginning and end of a test period. If the difference between the rainfall and the total gain could be accounted for by evaporation, it would be safe to presume that the drainage area was water-tight; if not, there might be proof that percolation water from outside sources was feeding the stream, or, on the other hand, indications of a serious loss of percolation water from the drainage area. In the latter case there would be warning that the installation of a dam might be unfortunate, or even disastrous. There has been sufficient evidence put forward by observers to show that the percolation drainage area is in some cases considerably different from the topographical drainage area, and to consider them as equivalent without satisfactory evidence that such was the case might be an unsound presumption.

Evaporation and Percolation Storage.—The rate of evaporation from water surfaces appears to follow an ill-defined relation to the power of the sun and the duration of sunshine, whilst wind also has a slight influence; but evaporation from a drainage area is influenced by other conditions, such as the soil, percolation rate, elevation and vegetation. The most important factor other than the sun is probably the capacity of the surface soil for moisture. The power of the soil to retain water is known as capillary attraction, and it is a power which defies to some extent the force of gravity. When these conflicting forces are balanced, the amount of water retained in the soil is relatively large (no doubt often equivalent to three inches of rainfall), but very variable, according to depth and fineness, and perhaps also variable with weather conditions. The power of evaporation, due largely to the influence of the sun, appears to be a stronger force than that of the capillary attraction of the soil, for the soil is robbed of part of its moisture, and therefore makes a toll of subsequent rainfall. It is doubtful whether the soil can take its full share from a particularly heavy fall as it requires too much time to do so, and consequently part of the rainfall percolates before the soil is fully satisfied. Though this latter point remains in doubt, it is quite clear that a large part of the evaporation loss in a dry period is replaced from subsequent rainfall, and at times there is but a small balance available to supplement stream flow. In hot, dry months evaporation loss from a drainage area is smaller in the absence of rain than it would otherwise be, because the moisture is not available for evaporation. The surface soil probably draws to some extent upon the subsoil immediately below it, for even vegetation which derives supplies from some depth below the surface has at such times difficulty in maintaining life. Evaporation cannot reduce the percolation storage where the latter is in deep subsoil, but may reduce very slightly the discharge from such a source by evaporation from the stream surface.

Figures quoted as calculated evaporation losses from drainage areas, though amended by the correction already suggested, would also include losses due to percolation water escaping from the drainage area, and for these reasons they are of doubtful value. The same remarks apply to the figures given in certain text-books to represent evaporation losses due to different forms of vegetation, as they are probably based on differences between rainfall and stream flow.

Investigations of loss by evaporation have been made by means of percolation gauges, but there does not appear to be such definite agreement between the records as might enable accurate conclusions to be deduced therefrom. It is difficult to see how soil and subsoil can be disturbed and placed in a percolation gauge in a condition equivalent to that in which they originally existed, and as in the usual form of percolation gauge no surface run-off is possible, the surface water is exposed to absorption and to evaporation influences for a longer time than it would be on a steep drainage area.

Lag.—This term appears to be frequently used to denote the time taken for percolation water to influence flow, and apparently is the result of investigations of the flow of the River Thames, in which there was shown to be a lag of five months between the maximum rainfall and the maximum flow, and the minimum rainfall and the minimum flow respectively. These results were obtained from average monthly figures of a period of twenty years, and it is very questionable whether it is correct to say that percolation water takes five months to reach the river. It is clear that it is not the total rainfall which constitutes flow, but only so much as is available after accounting for losses. If we were able to determine monthly evaporation losses and deduct them from the total monthly rainfall, we might make a diagram of "available rainfall," which from established facts would be relatively very small in summer, and very little different from total monthly rainfall in winter. If five months lag were allowed for, the minimum monthly flow from averages over a number of years would be expected about December, and the maximum flow about May; as this is so different from what actually occurs, it seems clear that the period of five months is incorrect, and moreover it is not even supported by actual monthly records of rainfall and flow. From monthly records of the flow of the Thames, it appears clear that there is no marked difference in point of time between the flow curve of the Thames and those of other British streams and rivers from areas in which geological conditions are a remarkable contrast. It might be reasonably expected that percolation from rain which falls near the banks of the river would feed the surface of saturation close to the river, causing some increase of flow within a very few days at most. It may be noted that percolation equivalent to one inch of rainfall might raise the surface of saturation by several feet if the fissures were of small size. The monthly records of the flow of the Thames appear to the author to show a measure of agreement with his conclusions based on observations from totally different sources; there are indications of depletion of percolation storage towards the end of the summer, and the filling up towards the end of the winter, where the maximum percolation discharge is most liable to occur in not only the Thames, but in every British stream or river.

Snow is another source of error in calculating evaporation losses from drainage areas; its presence, or any doubt as to its presence, spoils the value of comparisons of precipitation, flow and evaporation. Wherever gaugings are taken, weather conditions, and especially the existence of snow, should be recorded.

The maximum flood rate, or average rate of a short period, is of importance as the basis for determination of sizes of reservoir culverts and weirs. It is the custom to base calculations on the highest flood rate which obtained in a particular drainage area, and allow a little more to be "on the safe side." Though it may be safe, it is not a very scientific method of determination, for figures which apply to one area do not correctly apply to another. Flood discharge is chiefly surface run-off and is dependent upon a factor which varies for each area, and probably largely on intensity of rainfall, so that unless the latter has been observed in conjunction with stream flow, reliable estimates cannot be made for possible maximum rates.

The flow curve of a spring is that of percolation water alone. The author would expect a spring flow curve to have similar features to that of a stream flow curve were the "peaks" of the latter removed, and would expect the principles stated to be capable of application in most cases.

British View of Various Forms of Construction Contracts

By FREDERICK L. DORE,
President National Federation of Building Trades Employers of Great Britain.

From a paper presented before the Royal Institute of British Architects.

The first thought that suggests itself is to ask the question, Has the present system worked satisfactorily? The unanimous reply to this must unquestionably be a decided negative, and this, in my judgment, is wholly due to the present type of competitive tendering. To obtain a real and true competition and not a farcical one such as at present obtains, the first requirement is that the commodity supplied shall be the same. I ask anyone intimately acquainted with the building trade if such a condition of things exists at the present time? We find, I think, it will be generally agreed that building work has for many years been executed at far too cheap a rate, and that all parties concerned in its production have been inadequately remunerated.

In the first place, the workman has only received a bare living wage; the contractor, after providing interest on the capital invested in his premises, machinery, plant, etc., has had an exceedingly meager remuneration for his individual efforts; and, consequently, the architect has received his percentage on a considerably less sum than his work entitles him to; and the only person who has reaped the advantage is the building owner, who is often merely a speculator.

At the same time, some form of contract system is undoubtedly both desirable and necessary. The injury to the industry has in my judgment largely been brought about by the present inequitable system of competitive tendering. It has been responsible for a large portion of the inferior designed and the greater portion of the badly constructed and scamped work which has been produced during the last 50 years. Theoretically, a competitive system properly administered has much to commend it, if one presupposes that all persons entering into competition turn out exactly the same quality of work, in which case the man who adopts the best methods and has the best organization will reap the benefit of it and obtain the larger share of the work for which he tenders. (I do not think the percentage of profit he is satisfied with enters very much into the question, because it will be found that the inferior work bears very much higher rates of profit than the better class.) The architects, I am afraid, are not entirely free from blame in this matter, and have, especially in competitively-designed work, done something towards bringing about the present condition of things, because in their anxiety to give their client the very utmost for his money they have frequently, where perhaps there has been, say, $50,000 to spend, designed something that will cost $75,000, with the result that everything has had to be pared down to the lowest possible minimum; and the main object has been to get hold of a builder who will put it through, somehow, and a competition in which a whole crowd are invited to tender has resulted in totally different classes of work being pitted against each other; exactly the same effect is produced in the case of the client who asks for a $50,000 building when he has only $40,000 to spend. Such competitions, were it not so serious and unjust an infliction on reputable contractors, would be ludicrous.

It is, I think, largely from this cause that the competitive contract system has been brought into disrepute. We have heard repeatedly during the last two or three years, until it has almost become a platitude, that "things will be altogether different after the war." No doubt that is so, and nowhere will it be more apparent, I think, than the building industry, with the workmen requiring—and I consider very properly—that their remuneration shall be such as will enable them to put something by for old age and have more of the amenities of life than they have hitherto enjoyed with the changed standard of cost and mode of living. Great changes must inevitably ensue. This, together with the uncertainty of the cost of materials of all kinds, makes any contract for a fixed sum, where the work is likely to extend beyond a month or two, a gamble of the most reckless kind, and should, I venture to think, be utterly condemned and discouraged. That this view is a pretty correct one is demonstrated by the report of the committee set up by the government and presided over by Lord Colwyn, which recommends that for the next two or three years at least tenders for work should be based on a lump-sum profit irrespective of the cost. It is already in operation in several instances with, so far as my experience goes, very satisfactory results to all parties.

For the benefit of those not acquainted with the procedure I may briefly explain the working of it. The quantity surveyor, in addition to taking off the quantities, prices out the work at what he considers the fair cost value, and the contractor gives a quotation for the sum for which he will loan the necessary plant and accept as profit on the actual cost of the work; a further provision is usually inserted that any savings on the quantity surveyor's estimate of prime cost shall be equally divided between the employer and the contractor; for example, supposing the prime cost is estimated at $50,000, and the tender for plant and profit is $7,500, and at the end of the job the prime cost works out at $45,000, the contractor then receives $2,500 in addition to the $7,500, but if on the other hand it works out to $55,000 he then only receives the $7,500. It appears as though for the future three methods of contracting satisfactorily are available:

(1) The one which has been in operation up and down the country for many years, and on which many of the largest and best buildings have been erected—viz., a percentage on the cost. This, unfortunately, for the last two or three years has been somewhat under a cloud, and has been brought into disrepute owing to a large amount of work being done under these conditions by men who had crept into the trade and who were not builders, and the scandals which have arisen over many of the government contracts. But speaking from my own experience, I am sure it will be borne out by many other contractors, in the very large majority of cases it operates exceedingly well and to the satisfaction of all concerned.

(2) An agreed sum certified by the architect as being a fair and reasonable amount but without competition. It may seem extraordinary to some persons, but I can positively assert that under such conditions the contractor frequently obtains less profit than in sharp competitive work. When this course is adopted a confidence in the contractor which he recognizes is set up, and many matters small in themselves but which frequently aggregate to a considerable amount have to be carried out without charge, because the builder, owing to the confidence which has been reposed in him, feels himself unable to demand an extra for them, whereas in the case of keen competitive work every item, however small, is looked after, and quite properly has to be paid for. Of course, at the present moment, owing to the uncertainty of prices of both labor and materials, no lump-sum contracts can be entered into, except with the proviso for an up and down addition or reduction according to the fluctuations of the market.

(3) The system as recommended in the Colwyn Report to which I have already alluded. If this develops as satisfactorily, as so far it seems to do, I believe that not only may it apply for two or three years, but may form the basis on which the contract work in the future may in most cases be carried out. It will be urged by some that a client before commencing work wants to know exactly his commitments; my reply to that is, that a man proposing to build should not arrange to spend more than 80 per cent of what he can conveniently afford. We all know that the individual who nicely balances the expenditure on his living to the exact dollar of his income generally comes a cropper, because sooner or later some unexpected expenditure comes about, and he finds a balance on the wrong side. The unsatisfactory nature of the contract system is also the cause of the great difficulty the Royal Institute of British Architects and the National Federation of Building Trades Employers have experienced in devising a form of contract which was fair and equitable all round. Both the Royal Institute and the Federation have been respectively engaged for some time in preparing new forms, and I hope at an early date a joint conference will be held, when something more suitable to present-day requirements will be agreed upon. The present form would without doubt have been scrapped long ago but for the forbearance of our trade, and the common sense and equitable manner of interpretation adopted by the great mass of the architectural profession; as it at present exists it is, in ignorant or unscrupulous hands, capable of causing most unreasonable and unjust expense.

To take only one clause as an example—viz., that which gives the architect unlimited power to reject without appeal any material he may choose. I have a case in my mind where a man, absolutely ignorant of his profession and wholly dependent on others both for designing and carrying on his work, time and again objected to some of the finest materials that came into the market. Such cases are of course rare, but a contract to be equitable should render it impossible for such a case to occur.

Some kind of contract is not merely necessary but desirable for both parties to it, and I personally look forward very hopefully that with the development of the sytem recommended by the Colwyn Report and mutual agreement between the R. I. B. A. and our N. F. a form of contract will at no distant date be framed, whereby the old insane gamble and cut-throat system may become a thing of the past, and be superseded by one in which work may be carried out reasonably and well, and to the satisfaction of all parties concerned; and I believe that work will be produced which will mark the twentieth century as one in which the quality of building work all round reached an excellence such as it had never previously attained.

Power and Irrigation Project for Palestine.—A project for utilizing the level variation between the Mediterranean and the Dead Sea by means of power stations has been brought forward by Albert Hiorth, a Norwegian civil engineer. According to the Norwegian Trade Review, Mr. Hiorth's plan proposes a tunnel about 37 miles long, running east and west from the Mediterranean to the Dead Sea, passing under Jerusalem. This tunnel would carry the water from the Mediterranean to the western slopes of the lower end of the Jordan Valley. From this point the water would be directed through pipes down to the level of the Dead Sea, where a power plant with turbo-electric machinery would transform the water power into electricity, to be distributed as light and power throughout the country and drive a pumping plant at the southern end of the Lake of Genezareth. This power would be utilized in the following ways: For the production of lime nitrate from the air, and also for the extraction of the salts contained in the waters of the Dead Sea and for local mining operations (asphalt). For electric light and power throughout the country. For a pumping plant at the southern end of the Lake of Genezareth, which should be regulated by dams and by lowering the surface level, also possibly by making the River Jarmuk a tributary. At a suitable altitude above the normal water level, two canals would be built running from the lake parallel with the River Jordan, and from these canals the irrigation water would be distributed to the local irrigation centers among the freshly cultivated fields, sloping, for drainage, toward the Jordan. By economizing the water during the dry season, and by a thorough regulation even above the Lake of Genezareth, there would thus be obtained an ample supply of water for the irrigation of several hundred thousand acres. For large salt works to produce common salt from sea water. The water would evaporate, and the salt could be collected in the ordinary way. For reclaiming the shallow southern part of the Dead Sea, by means of a dam from Lison westward (the present ford); and for the exploitation of the vast deposits of asphalt in the plains of Sodom and Gomorrah. The geological maps of the country indicate what would appear to be very favorable conditions for the boring of a tunnel, although progress might be delayed by hot springs. According to the Norwegian Trade Review, the cost of the Dead Sea tunnel (double), mostly without masonry and with a minimum area of 135 sq. ft., would approximate $40,000,000.

Hydraulic Rock Blasting.—A hydraulic device for the blasting of rock, and especially also for the demolition of concrete piers and foundations, is briefly described in the Zeitschrift für Schiesswesen of May 2, 1919. The device is due to Dr. Tubben, of the Armaturenfabrik Westfalia. A pressure pipe leads to a cylinder, 85 mm. diameter, in which eight pistons move, one after the other in telescope fashion. The cylinder is inserted into a hole drilled into the rock by an electric motor; the pistons are forced out and crack the rock. The drilling of the holes, about 1 in. in depth, is said to take 15 to 20 minutes, the blasting five minutes. When the rock has been cracked, a tap is opened and the water allowed to spurt back. The device is said to have proved very successful in mines and quarries, where the concussions of explosives would be dangerous.

Wood as Reinforcement for Concrete

From Beton u Eisen, 1919, pp. 85-88

Experimental beams 2¾ in. wide and 4 in. high and 7 ft. 4 in. long were mounted on knife edges 6 ft. 7 in. apart The arrangement of the reinforcement in these beams is shown in Fig. 1. The measurements in these illustrations are in 25ths of an inch. The reinforcing wires were fixed at the usual angle of 45°, eight wires being used.

Beam a was the customary type of reinforcement with 1.35 per cent of steel, and was used principally to find the elasticity ratio $n = \frac{Ee}{Eb}$ of the concrete, and the corresponding ratio of wood concrete $m = \frac{Eh}{Eb}$

Beams c, d, e, and f were reinforced with wood and wire, the wooden bars being 8 ft. by 3¼ in. by 3¼ in. The breaking loads obtained with these beams showed that more wood was required as reinforcement. On doubling the amount of wood (beam f) the breaking load was also doubled, but owing to shearing no really satisfactory breaking load could be obtained.

Even worse results were obtained with a wooden plank (beam g) in which the reinforcement was 7 per cent of the concrete and wires were fixed in position by means of wedges.

Beams m, n, and o, made of magnesite concrete, gave higher breaking loads.

A wooden beam of the same size as the concrete ones had a breaking load greater than beams a to n, but rather less than beam o.

The relative strength of beams of wood (1) wood-concrete (2), and reinforced concrete (3) is shown in Fig. 3. As indicated in the illustration, a wooden beam may be replaced by a concrete beam containing 20 per cent of wood and a concrete beam with only 1 per cent of steel reinforcement. As wood is more liable to contain defects than steel, its factor of safety should be 5, while that of steel may be 2½.

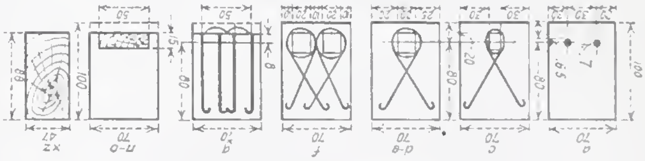


Fig. 1—Arrangement of Reinforcement in Experimental Beams.

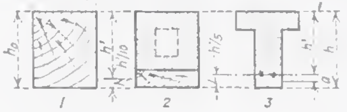


Fig. 2—Diagramatic Representation of Relative Strength of Beams.

This investigation also provides a means for overcoming some of the difficulties due to a shortage of timber, as in wood-concrete beams much less wood is employed, and in them the pieces of wood may be merely bolted or screwed together to form a reinforcing member of the requisite size, whereas in a wholly wooden beam special precautions must be taken with regard to joints.

Wood-concrete may advantageously be used instead of ferro-concrete in light structures and generally in cases where wooden beams would ordinarily be used.

A summary of the results of the tests is given in Table I.

TABLE I.

Beam.	Width, cm.	Static ht., cm.	Reinforcement.	Per cent	Weight of beam per lin kg. meter	Breaking load.
a..........	7	8	2R.—E 7 mm	1.37	17.3	552.5
c..........	7	8	1 × 2 cm.	3.57	16.3	199.2
d..........	7	8	2 × 2 cm.	7.15	15.6	338.8
e..........	7	8	2 × 2 cm.	7.15	15.6	385.3
f..........	7	8	2 × 4 cm.	14.3	15.0	449.5
g..........	7	8	5 × 0.8 cm.	7.15	11.8	321.5
m..........	7	8	5 × 0.8 cm.	7.15	12.4	511.8
n..........	7	8	5 × 1.6 cm.	14.3	13.0	653.0
o..........	7	8	5 × 1.6 cm.	14.3	13.8	833.7
x..........	4.1	8.8	0	....	1.7	631.2
z..........	4.2	8.8	0	....	1.5	701.0

Stress Measurement of Bridges

From The Engineer, London, Aug. 1 and 8, 1919.

The measurement of stress as distinguished from the calculation of stress is a matter that will soon become of importance, and is one of the lines along which bridge engineering will be further developed. Reliable information concerning the actual intensities of working stresses in main members of bridges, and especially in their connection details is very meager, notwithstanding the fact that such information would be of inestimable value to all designers of steel bridges. The importance of stress measurements is so great that it might be said that such investigations in the future will prove one of the most useful aids in the design of bridges of all types, and not only of those of unprecedented span.

When bridges are of great span there are secondary stresses to consider as well as primary stresses, and they cannot always be satisfactorily found by calculation, which must be derived from assumptions; but even in smaller metallic bridges, even where secondary stresses probably do not exist, it would be a manifest advantage to know the actual as compared with the calculated stress. The actual measurement of stresses is a matter that must depend upon the quick application of easily read and dependable instruments and gauges.

From these findings, particularly in connection with secondary stresses, the design of bridges may be improved and made more rational and certain, and they will correct or confirm the results of theoretical analysis. Furthermore, it is by no means certain that the methods will be devoted to bridge work only. This experimental verification of stress conditions will be found particularly desirable in previously unexplored engineering fields, or wherever there are special features which may produce uncertain variations from calculated and assumed conditions. Up to the moment theoretical analysis is far in advance of experimental verification, but there is certainly a growing movement towards experimental investigation, as evidenced by the many tests of full size compression members, and in load tests of bridges. The subject of measured strains opens the way to advance knowledge relating to the actual conditions or states of strain which pertain to engineering structures of all kinds.

The measurement of stress has only been found practicable within the last few decades. In 1883 Professor Frankel applied his extensometer to ascertaining experimentally the true values of secondary stresses in bridge members, and his published results in Der Civilingenieur had the effect of inducing some foreign engineers to abandon the use of riveted connections in favor of pin connections, with the use of which it was assumed secondary stresses could not by any possibility exist.

Where a mechanical extensometer of sufficient delicacy is not available an optical method of measuring the extensions has been devised. The method consists in measuring upon a screen the optically projected magnified image of the gap produced by the separation of two knife edges fastened to the test piece, the projection of the image being in all respects similar to that employed in microphotography. A source of light being placed behind the knife edge, the gap is magnified under a microscope having a projecting eyepiece and camera extensions in such a manner that the degree of magnification may be readily ascertained. The test piece having been placed in position in the testing machine, with the knife edges properly adjusted, the source of light is focused on the back of the knife edges, the gap is carefully focused upon the screen, and the width of its image is measured by means of a vernier. A known load is then applied, and the width of the image of the gap is again measured. The difference of the two readings gives the extension due to the load applied. This process, having been repeated for a series of increasing loads, readings are obtained which enable a stress-strain diagram to be plotted, and the modulus of elasticity of the test piece to be determined. By substituting for the screen a photographic plate contained in a dark slide, a photograph of the image of the gap may be obtained. By the combination of the microscope, camera, and vernier, the extensions can be measured accurately to $^{1}/_{100000}$ in.

Professor Coker's apparatus for the optical determination of stress consists primarily of two Nicol rhombs, a polarizer, and an analyzer. If a beam of ordinary white light is passed through the two rhombs and focused on a screen, and the analyzer is rotated, the light is transmitted or cut off according as the rhombs are parallel or crossed. If a thin slice of colorless crystal of uniform thickness is placed between the two rhombs, the transmitted light is of a uniform color, say, blue, and by rotating the analyzer through 90° the complementary color, yellow, is obtained. For investigations of stress a piece of celluloid is placed at an angle of 45° in this apparatus. A pull is then transmitted to it, and the amounts of the load recorded. The colors change with the amount of the pull, each color or shade corresponding to a definite intensity of stress, which can be easily calculated if the specimen is of some simple regular shape, resulting in a uniform intensity of stress throughout it.

In 1889 Mesnager measured the stresses in some of the web members of a bridge of 180 ft. span on the Orleans railway of France, by means of the Rabut extensometer, and described the work in the Annales des Ponts des Chausées.

The instruments were fixed at four points of the cross section near each end of a member. The results thus ascertained experimentally gave similar results to those found by calculation as regards the stress carried by the member as a whole, but, remarkably enough, the stress was not found to be uniform throughout the cross sectional area of the bar, there being considerable differences between the actual stresses on the opposite sides of the bar. In the compression members secondary stresses, amounting to 200 per cent of the direct stress, were found to exist, and in some cases there was a complete reversal of stress, from calculated compression to actual tension on one side of the member. In the diagonal members secondary stresses of a value of 45 per cent of the calculated direct stress were found to exist. Such results showed that the design of the structure was by no means so perfect as was desirable.

In 1901 some further experiments were made on the bridges of the Orleans railway, and were also described in the Annales des Ponts et Chausées. The investigations were carried out on comparatively small trussed and plate girder spans, and interesting results were achieved. Some of the plate girder bridges which had been supposed to carry heavy stresses were found by the experimental method to be carrying much lighter stresses. In cases where longitudinal ties under the rails were carried on plate girders, the latter were found to be acting as girders having fixed ends, the stresses actually in the center of the span being much less than those calculated, and with reversed stresses at the ends. In truss bridges of small span secondary stresses of 30 per cent value were found to exist at the outside of the upper chord, and were found to be due to the deflection of the cross beams, causing the top of the main girders to move laterally inwards.

The bottom chords of some of the bridges took less stress than the upper chords owing to a certain amount of the stress in the bottom chord being taken gratuitously by the rail longitudinals or stringers and the bottom laterals. The cross girders, with ends riveted to the main girders, were found to act only as simple beams, the end restraint of the riveted connections being negligible. Rail longitudinals acted as simple beams when loaded between the cross girders, and as girders with fixed ends when the load was symmetrically disposed on both sides of the cross girder.

This experimental verification method shows the necessity for providing for negative bending moments where longitudinal rail bearers are riveted to cross girders, the need for making the longitudinals as deep as possible to obviate torsional stresses in the cross girders, and the importance of making the cross girders with as much depth as possible to obviate transverse bending of the main girders of the bridge.

It may be remarked that the bridges upon which the experiments were made were of comparatively small span, and not of the largest and most important spans in existence. It should also be noted that the effect of the dead load, or of the erection of the structure, could not be determined in any of the cases we have cited.

This deficiency was more than made up by the experimental tests carried out on the recently built Hell Gate Arch Bridge over the East River in New York, under the direction of Mr. Lindenthal.

The trusses of the bridge are doubly intermediate, they are two-hinged arches, and they have redundant members in the center panel. It appeared therefore to be of interest to demonstrate, by measurements, the identity of calculated and actual stresses in the finished structure. A further other purpose of extensometer measurements was to supply a safeguard during erection by measuring the stresses at critical points. The stresses in the arch members and in the back stays were thus measured in the successive stages as the work was built out, panel by panel, to their junction at mid-span.

When any of the stresses were reaching their maximum values they were closely watched. For instance, one of the eye-bars in the forward stay was found to have a stress 55 per cent in excess of the average stress in the group. As the erection progressed the difference in stress gradually diminished until all the eye-bars were found to be uniformly stressed to nearly 20,000 lb. per square inch.

Another application of the extensometer was to provide a check in some of the critical operations of the erection. After seven panels had been erected the hydraulic jacks at the tops of the towers were operated to put the forward or upper stay in tension and release the lower stay. This operation was checked by the extensometer in both stays. When the operation was carried out on the Wards Island side it was found that there was a slight compression in the lower stay, indicating that the jack had gone too far, and the jacks were then released until no stress was found in the lower stay.

After the trusses met in mid-span the lowering of the jacks to close the arch was closely followed by measuring the diminishing stress in the forward or upper stay. Measurements were also made in the central chord member to make sure there was no excentricity of bearing at the juncture of the two half arches.

The final operation of closing the top chord at the crown was also checked by the extensometer. A large bolt held the members together, until the drilling and riveting could be done. The bolt had to be adjusted to a condition corresponding to zero stress at 60° F. The instrument checked this operation and the subsequent stresses in the top chord member.

The final use of the extensometer was to provide a comparison between the calculated and actual secondary stresses in the structure.

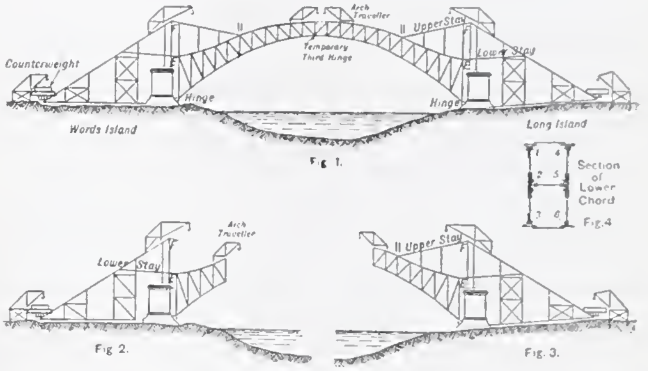
The instrument used was the 20-in. strain gauge, designed by Mr. James E. Howard, which is essentially a micrometer calliper. The measuring points are hard steel conical points attached to the barrel and the rod respectively, the distance between the two points being measured by a micrometer contact screw at one end of the barrel, reading by a circumferential vernier to 1/10,000 in. A rectangular steel bar, provided with two center holes 20 in. apart, accompanies the instrument, and when a reading is made a comparison reading is made on the bar, the difference between the two readings being the measurement. The same observer always takes the two readings to eliminate the "personal equation." The steel bar is allowed to rest on the member of the truss, so that the temperature shall be the same, but nevertheless a thermometer is attached to the bar and another to the member so that any required correction can be made.

Another related instrument is a steel trammel bar having prick punches 20 in. apart, and is used for setting out the holes in the member. Of course the holes are carefully drilled and cleaned before taking any readings. This method of measuring strains has been used in an examination of the dead load strains in bridges of large span in the structural members of modern buildings, in the distribution of stresses in the sheets, and across the seams in large boilers, in the investigation of the internal strains in steel rails, and also in the study of thermal effects in street pavements. It has also been used to ascertain the internal strains in steel forgings, in railway axles, in cold rolled shafting, and the residual strains in steel bars after over-straining loads had been applied and released.

In any member it is necessary to have three or four measurements near each end of the cross section. The lower chords of the Hell Gate Bridge are of a double rectangular section—see Fig. 4. On account of the mass of metal near the center diaphragm, it was considered that measurements at the four extreme corners of the section would not be fairly representative of the entire area. Any difference of temperature between the diaphragm and the outside webs would produce internal stresses in the member. It was therefore judged necessary to take six readings at each cross section, as shown in Fig. 4, there being twelve gauge points in each member, each gauge point consisting of two drilled holes 20 in. apart. All measurements were taken in the inside of the member, thus affording protection for the gauge points from rain and dirt, and also securing greater protection for the observers. More than 3,000 measurements were taken in the members, besides special measurements in the back stays and eye-bars links.

The primary stress measurements were in general confined to the lower chord members, as they are the most important parts of the structure, carrying nearly all the dead load and the live load when covering the whole span. In the case of the secondary stresses, measurements were also taken for the upper chord, the diagonals, and the verticals.

By arranging the six measured stresses at one end of a member, and then repeating for the other end of the member, a comparison was made between the two sets of values, and the comparison gave an index to the accuracy of the results. The average of this difference was 140 lb. per square inch, the maximum difference being 500 lb. per square inch, and these figures represent the combined effect of personal and instrumental errors, but can be accounted for by a very small error in the readings, and would occur by an inaccuracy of 2/10,000 in. in each micrometer reading, and of 1° F. temperature reading.



Erection Methods for Hell Gate Bridge.

It was observed that the magnitude of the differences between the end measurements had no connection with the magnitude of the respective stresses, indicating the unsuitableness of the method for the smaller stresses of less than, say, 1,000 lb. per square inch.

In the final or two-hinge stage it was noted that in the members near the ends of the span the upper end in every case was found to present a larger average stress than the lower end, the differences ranging from 450 lb. to 2,800 lb. per square inch.

A comparison of measured and calculated stresses showed a still greater discrepancy. For stresses of the range 0 to 1,000 the average discrepancy was 50 per cent, from 1,000 to 3,000, 17 per cent, descending to the range 10,000 to 20,000 when the discrepancy was only 6 per cent, indicating that the method is of little value for lower stresses, but is of increasing value as the intensity of the stress increases.

The most important of the physical errors was found to be due to thermal effects, an error or a change of 1° F. producing an error of 195 lb. per square inch. Such errors are not necessarily due to incorrect readings of the thermometer, but may be caused by a difference in temperature between the inside and outside of the web plates forming the member, and on a sunny day the outside web and covers may be hotter than the middle diaphragm, showing that a cloudy day should be selected for such work

One important error may occur in the assumption of 30,000,000 as the value of the modulus of elasticity during the conversion of the measured strains into intensities of stress. There may easily be a percentage variation of ± 3 per cent.

But the whole consideration proves the futility of excessive refinement in the calculation of stresses.

A comparison was also made to establish a relation between the average primary stresses and the extreme variations from these average secondary stresses in the members of the structure. Such secondary stresses include those due to the bending of the members in the plane of the truss, possibly due to their own weight, and any horizontal or lateral bending stresses from wind and transverse strains, shop inaccuracies, internal temperature strains, erection strains, lack of uniformity of materials, etc.

The difference was taken between the average of the twelve measurements in one member, and that of the twelve varying the most from the average.

For primary stresses of the range 0—1,000 the extreme secondary stress averaged 268 per cent, decreasing for the range 7,000—8,000 to 32 per cent, indicating the diminishing relative importance of secondary stresses with increasing primary stresses. But although the percentages diminish in this way the absolute values increase, averaging 1,580 lb. per square inch in the lowest range up to 2,370 lb. per square inch in the highest range. In 100 cases the greatest extreme secondary stress was 3,700 lb. per square inch.

Another comparison was made between the calculated and the measured secondary stresses, and in order, for comparison with the calculated secondary stresses, due to the bending of the members in the plane of the truss, the measured secondary stresses was defined as one-half the difference between the average measured stresses in the top and bottom fibers of the cross section, and lateral variation had to be ignored. The average of the calculated secondary stresses for all bottom chords, and all erection stages was about 1,050 lb. per square inch, while the average of all measured secondary stresses was only 700 lb. per square inch. The highest calculated secondary stress in any stage was 2,920, and the corresponding measured stress 1,990 lb. per square inch. For the purpose of comparison, both the measured and the calculated values were reduced to percentages of the corresponding primary stresses. It was found that the high percentages always occurred with low primary stresses.

If the secondary stresses were grouped and averaged in ranges of percentages it was found that in the range 0—20 per cent the average calculated secondary stresses were 6 per cent, and the corresponding average measured secondary stresses were 26 per cent, respectively. For the range 20—40 per cent the corresponding figures are 30 per cent and 28 per cent, and for the range 100—300 per cent the corresponding figures were 143 per cent and 93 per cent.

Except for the smaller percentage of secondary stresses the measured values were consistently lower than the calculated values, and as the percentage of calculated stresses increased the percentage of measured values also increased, but not as rapidly. Furthermore, for the highest percentages of secondary stresses, the measured values amounted to only a small fraction of the calculated values. It may therefore be concluded that the actual secondary stresses are generally lower than the calculated values.

When the final stage was reached, and the structure became a true two-hinged arch, the extreme fiber stresses, representing the maximum combination of primary and secondary stresses, were found to vary from the first bottom member against the abutment with a calculated value of 12,160 and a measured value of 11,300, to the central bottom member in mid-span with a calculated value of 13,270 and a measured value of 13,300, a truly remarkable agreement.

It was concluded from the series of measurements that the Howard strain gauge is well adapted for such work under quiescent load, provided the stresses are more than 1,000 lb. per square inch; that with careful manipulation it is possible to determine the true stresses within less than 200 lb. per square inch, and that there is generally an automatic readjustment of strains within a structure in such direction as to relieve the secondary stresses. There was proof also of the release of strains at joints when the drift pins were replaced by rivets, and the whole consideration was taken to indicate the comparative freedom of the arch type from secondary stresses.

The Hell Gate arch tests, incomplete as they are, constitute an excellent example of the investigation of stress distribution, but they should be completed so as to include the effects of moving loads.

The criticism has been advanced that the principle of measurement of the Howard extensometer appears fundamentally unreliable in that the measuring points of the micrometer caliper are conical, and the zero reading for any given temperature is taken from a comparison bar with holes. The member to be measured has similar conical holes for the insertion of the micrometer measuring points. The bearing of the measured points may, it is said, be on the sides of the holes, and not on the tips. It has, however, been pointed out that a slight deviation from the perpendicular produces an entirely negligible error.

Further, it is said to be a most difficult matter to get a satisfactory micrometer "feel" with conical points bearing against the inclined sides of the holes, and in the confined space and disadvantageous conditions in which the measurements were taken, it must be difficult to obtain the thorough cleaning out of the holes so necessary for accuracy. Even a film of oil, may, it is said, upset the measurements entirely.

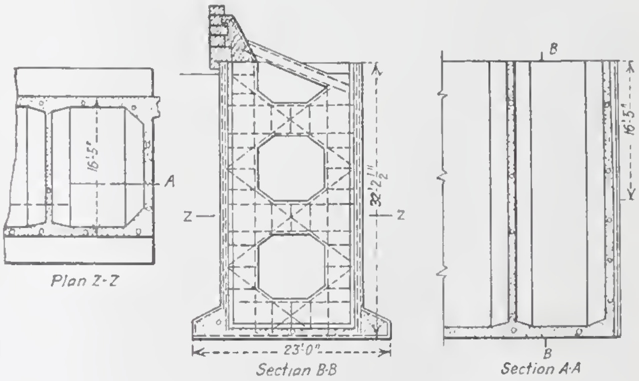
Cylindrical studs of small diameter were suggested with the comparison bar a plain rod. It has, however, been since pointed out that the gauge holes were, as a matter of fact, very well cleaned out, the operation actually taking up more time than the measurements.

The criticism has also been offered that the gauge length of 20 in. was perhaps too great to give the maximum intensity of stress. There has been found a considerable difference with other tests in local stress between a 2-in. and an 8-in. gauge length. It seems, therefore, that the intensities of secondary stresses may be greater in some parts of the metal than the average over 20-in. length, and that they are intensified again at the edge of the gusset plates. It may not be well to minimize these stresses, as doing so would tend to give unwarranted confidence, and possibly result in overlooking secondary stresses. It has, however, been suggested that the length of the Hell Gate bridge members was great enough to cause such possible variation of stress to be practically negligible, and the use of a shorter instrument would have offered no advantage to compensate for the reduced accuracy of the results.

The modulus of elasticity of the steel in the bridge was assumed to be 30,000,000.

Reinforced Concrete Caissons

It is often convenient to construct caissons on slipways in a similar manner to a concrete vessel, launch them and tow them to the required site and then to fill them with sand or other similar materials so as to sink them. The reinforcement of these caissons in general is similar to that of a concrete vessel. The accompanying drawing, reproduced from Concrete and Constructional Engineering, London shows some details of caissons constructed at Copenhagen. These caissons are stiffened internally by means of crossbeams 4 ft. 3 in. deep, spaced on 10-ft. 9-in. centers. In a caisson forming the lower part of the beacon at Alexandria, erected in 1911, a sole 40 ft. by 37 ft. and 8 in. thick is reinforced by transverse flat bars and a longitudinal joist, and joined to the caisson by 18 triangular buttresses. The walls of the caissons are 6 in. thick. There is a central column, 12 in. square, with four radiating groups of eight horizontal beams, each 8 in. square, and four oblique beams for stiffening the caissons during immersion. The caisson was built on a slipway, launched, towed 2½ miles, and then filled with water by pumping and so sunk.



Reinforced Concrete Caissons, Copenhagen.

Renewal of Worn Road Roller Wheels.—Renewal of worn wheels of steam road rollers by steel plating was first carried out by the Oxford Steam Plough Co., Ltd., according to The Surveyor, which states the best results are obtained if the wheels are plated when worn down to about 1¼ in. thick, the steel plates bringing them up to approximately their original thickness. The plates are fitted in four sections to each wheel, and after being thoroughly bedded to the camber of the wheel by hydraulic pressure, they are drilled and countersunk, and afterwards riveted to the original rim by a powerful hydraulic riveter. When this is done the wheels are placed in a large, heavy lathe and the edges of the steel plates turned off flush with the original cast-iron rim, so that when completed it is practically impossible to tell that the wheels have been so treated.

New Type of Lime and Soda Softening Plant for Water Purification

From The Surveyor, London, Aug. 15, 1919.

Patent Specification No. 9876/18 (accepted June 16, 1919), which has just been published, describes a new type of lime and soda softening plant, which contains some new and interesting features. An automatic flushing syphon is used for measuring the quantity of hard water to be softened, also for the mixing of the chemical reagents and the hard water together, and the automatic stirring up of precipitated lime left in the bottom of the reaction chamber, where it has been deposited from previous settlings, with a view of assisting the new settlings to settle rapidly. Another feature of the plant is the automatic measuring valve for the accurate measuring of the chemical reagents, and a very simple method for making a standard solution of lime-water from cream of lime without using a number of costly lime towers or saturators.

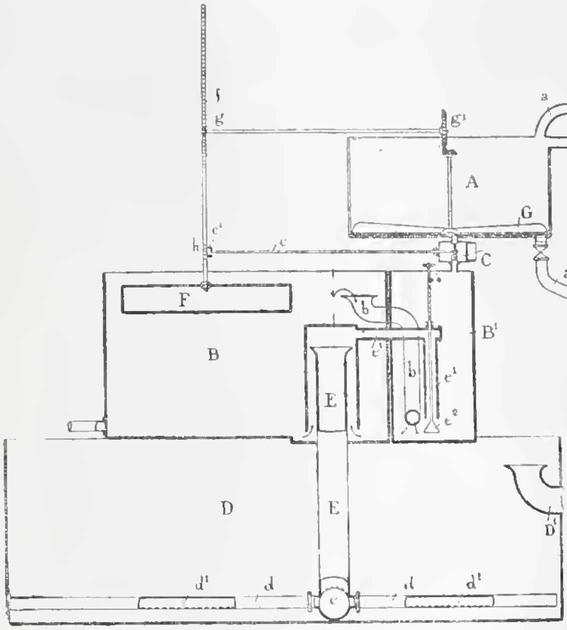


Fig. 1.—Vertical Section Through Plant.

The invention will be fully described with reference to the accompanying drawings, in which it is shown applied to a water softening and purifying plant.

The plant comprises a chemical reagent container A provided with an inlet supply pipe a connected with the chemical reservoir (not shown), such as lime-slaking tank where lime is employed, and not an overflow pipe a¹ and drain a², also connected with the chemical reservoir. Below the chemical reagent container A is arranged a second tank divided into two compartments, B and B¹, the larger compartment B serving as the hard-water measuring chamber, and the smaller compartment B¹ receiving measured quantities of chemicals from the tank A through the measuring valve C. Below the tank B B¹ is arranged a third tank D, at the bottom of which are two or more rows of pipes d, in which holes d¹ are drilled, the holes d¹ being on the underside of the pipes. The perforated pipes d are connected to the discharge pipe e of an automatic flushing syphon E, situated in the hard-water measuring tank B.

Connected to the upper portion of the dome of the siphon E are one or more suction pipes e¹, the other end or ends of which are connected to the tank B¹, receiving measured quantities of chemicals from the tank A. A regulating valve e² is arranged at the inlet end of the suction pipe e¹ to regulate the flow of liquid from the compartment B¹ through the suction pipe e¹. A float F is arranged in the compartment B, and a vertical rack f affixed thereto operates through the pinion g and bevel gearing g¹, stirring or agitating paddles G in the chemical regent container A. A projection h on the lower portion of the rod carrying the rack f is arranged to engage the cranked end c¹ of the shaft a spindle c of the valve C so that the movement of the float F brings about a partial rotation of the shaft or spindle c of the valve C. (The valve C does not form any part of this invention per se, but is described and claimed in a further Application for Patent No. 15819, of 1918.)

The tank B B¹ is fitted at any suitable height above the agitating pipes in order to give the required head for the stirring up of the precipitate in the bottom of the tank D.

In operation a concentrated solution of the water-softening reagent is supplied to the container A, and the hard water to softened flows continuously into the compartment B. As the water in the compartment B rises, the float in this compartment operates the measuring valve C, which delivers a measured quantity of the concentrated solution of the water-softening reagent to the compartment B¹, where it is automatically made into a weak standard solution of the chemical reagent by the addition of a given quantity of water from the compartment B. The compartments B and B¹ are connected together by a suitable pipe b, the inlet of which is below the top water-level of the hard-water compartment B, and the outlet at the bottom of the compartment B¹. On the water in the compartment B reaching the bell-mouthed inlet of the connecting pipe it commences to fill the compartment B¹ to a similar height as itself, the flowing of the water between the two compartments stirs up the concentrated solution of the softening reagent previously delivered from the measuring valve C and makes it into a weak standard strength. When the water in the compartment B has reached a certain fixed height the siphon E comes into action, sucking the hard-water into the siphon E and discharging it into siphon delivery pipe e. At the same instant the siphon commences to suck the hard water, it also commences to suck the weak standard solution of the chemical solution through the suction pipe e¹ from the reagent compartment B¹, thoroughly mixing and proportioning the hard water and the chemical softening reagents.

The reaction between the chemical softening reagents and the hard water commences the moment the two come together in the siphon dome. The mixture flows down the discharge pipe e and rushes through the holes d¹ in the agitating pipes d which are fitted in the tank D; the softened water in rushing through the holes of the agitating pipes stirs up the precipitate which has been deposited in the bottom of the tank from previous mixings, and this precipitate, being older and heavier than the precipitate from the new mixing, assists the new precipitate to settle rapidly, the new and lighter precipitate adhering to the older and heavier precipitate. The falling of the whole of the precipitate, with the resulting clearing of the softened water, saves the cost of a number of settling ponds or tanks.

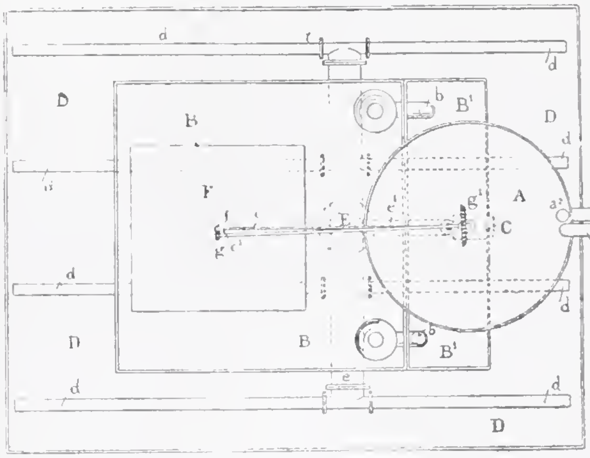


Fig. 2—Plan of Plant.

The cleared and softened water flows out of the tank D through the outlet D¹, which if desired may lead the water to a final settling tank.

The first of these plants is being erected at the works of the Ilkeston and Heanor Water Board, where a 2,500,000-gal per day intermittent softening plant is being converted. In this plant all the tanks now existing are being utilized for the new plant, and the alteration will be carried out without interfering with the working of the existing intermittent plant. When softening water at the rate of 2,500,000 gal. per day a saving of coal to the value of £1,625 ($7,897) per annum will be effected by the installation of the new plant, basing the present price of coal at 28s. 6d. ($6.84) per ton, delivered at the works; also a saving of labor will be effected by the alteration, the new plant being automatic and continuous. The patentee of this plant is Mr. Alfred E. Smith, engineer and manager of the Ilkeston and Heanor Water Board.

Sewage Clarification Tank at Auguste Victoria Colliery

By W. HAVERKAMP,

From Water and Water Engineering, London, Sept. 20, 1919.

To save the expense of loading, carting, emptying and cleaning the privy drums, which gave constant work to two men and a cart for conveyance to local farmers, the Auguste Victoria colliery, Hüls, has installed a clarification tank about 100 yd. from the No. 1 shaft. The drums are run, in pit tubs, along the high-level bridge leading to the pit mound, and on arriving at the tank are lifted by a light swing crane, emptied, thoroughly steamed out, rinsed with water, and returned to the pit. The contents and rinsing water are delivered through a pipe into the tank, the effluent from which is discharged into the colliery drain.

The tank is designed to deal with 150 cu. m. (33,000 gal.) of liquid per diem, and by spreading this quantity over a working day of 10 hours, the maximum flow is a little under 1 gal. per second.

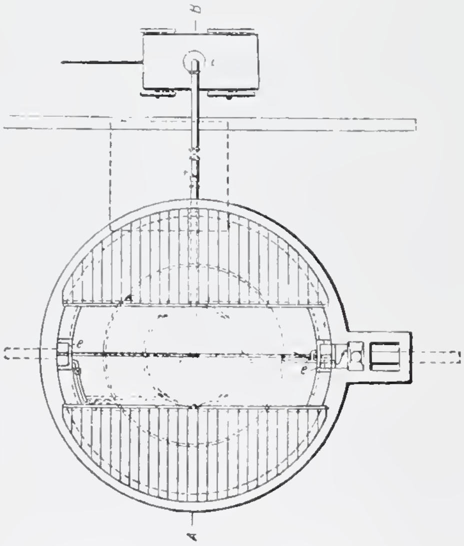


Fig. 1—View of Tank From Above.

The tank (Figs. 1 and 2), which is 7 m. in diameter, and has a water depth of about 9 m., contains a ferro-concrete settling hopper a, the lower portion b constituting the septic and sediment chamber. In the bottom of the settling hopper are two apertures c, and under the cover are two rows of similar apertures d. The heavy matters fall through the aperatures c into the sediment chamber d, while the lighter constituents escape into the septic chamber through d. In this way the effluent water is separated from both the heavier and lighter matters all the time it is passing through the tank.

The sloping cover of the settling hopper increases the frictional area and frictional resistance for separating the colloids, and thus increases the clarifying action; and the fact that the hopper is situated below the water level prevents frothing and spurting. The superficial area of the hopper is about 2.15 square miles, and the average velocity of flow is 1.95 mm., so that the contents require about 1½ hours to pass through.

The water intake (on the left hand of Fig. 1) delivers underneath the level of the liquid in the tank, and is exactly opposite the outlet. Both are of the same width as the broadest part of the settling hopper, in order to ensure uniform flow of the effluent and prevent currents, eddies and dead points. Traps e are provided at both intake and outlet, to retain any floating matter, and the outlet is also provided with a sill f to ensure uniformity of outflow.

The septic chamber has an effective capacity of 200 cu. m. (44,000 gal.,), and is able to accommodate the sediment from 100 days' supply. The removal of the sediment is facilitated by the sloping bottom of the chamber and by the water flush supplied through the perforations of the flushing coils g. This continuous small supply of fresh water has a known beneficial influence on the fermentation and sweetening of the sediment.

The spent water is removed gradually—in order not to interfere with the septic process—by special pipes connected with the outlet.

The septic chamber acts like a biological installation, and, therefore, requires a certain time to get properly into operation. If the sediment is not required to be liquefied, the ripening may be completed in about six weeks, though it may take over a year.

The sediment can be discharged on to the pit mound, about 90 yd. away, by means of the suction pipe h, and an electrically driven suction and force pump, assisted by the pressure of the column of water in the tank, but for the time being it is delivered into wheeled sludge tanks i.

The clarifying action of the plant is satisfactory, and there is no smell. The cost of the tank was about £560, the drum-cleaning plant £42, the drainage piping £30, alterations to the bridge £35, and the steam and water pipe connections £25. Formerly, the cartage of the sewage cost about 17s. per diem, or with five deliveries a week, £221 per annum. With the new plant, one man can attend to the cleaning of the drums at a cost (on the pre-war basis of 5s. per shift) of £75 per annum, the saving thus effected being 21 per cent on the cost of the plant.

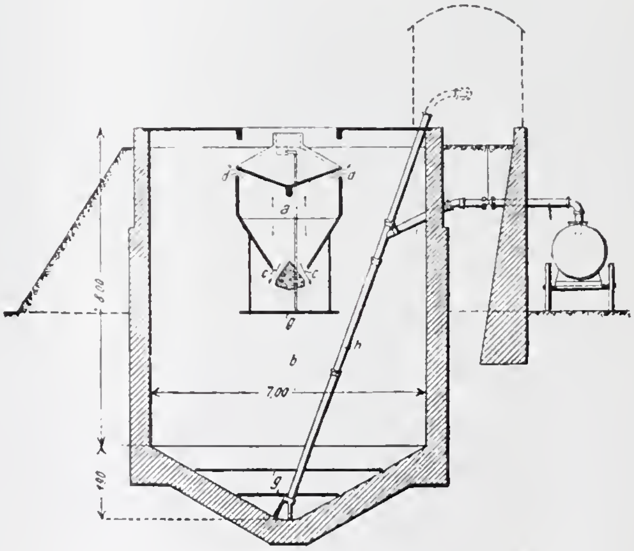


Fig. 2—Section Through Tank Along A-B of Fig. 1.

The tank has been working since the autumn of 1918, and has been very successful. The sediment is completely decomposed, and is nearly black in color.

Reinforced Concrete Poles for Transmission Lines.—Reinforced concrete poles were used in the construction of a 60,000-volt high tension transmission line, 40 km. in length, built in 1917-18, from Striesen to Dresden. Elektrotechnische Zeitschrift, Berlin, of April 24, 1919, states that the poles were constructed by a centrifugal process by Dyckerhoff & Widmann of Dresden. Their height varied between 15 m. and 18 m. In the longer poles joints had to be made by iron rings fixed in position by screws. Technische Blatt, Berlin, of May 31, 1919, also contains information on reinforced concrete poles for transmission lines. According to that journal the usual length of such poles ranges from 50 ft. to 60 ft. when spaced at intervals of 100 yd. and calculated for a top-tension of 450 lb. Corner poles may be subjected to a top-tension of three tons The former are reinforced with commercial mild steel and the latter with steel having an ultimate tensile strength of 85 to 100 tons per square inch. The poles are cast in wooden moulds containing a steel skeleton. Concrete in proportion of 1 of cement to 4 of conglomerate is then introduced in a fairly fluid condition, and the mould placed longitudinally in a machine which revolves at a high speed. All surplus water is thus expelled, and the concrete deposits round the steel skeleton in a few minutes. The pole remains 24 hours in the mould before undergoing a two days' drying process in moist sand. When completely set it is tested for elasticity and strength in a special machine.

Causes of Offensive Odors from Sewers and Remedial Measures

By EDWARD B SAVAGE,

Engineer in Charge of Sewers, Birmingham, England.

From a paper presented before the Institute of Municipal and County Engineers.

Following the same lines as many engineers, the author for several years carried out extensive anemometer and other tests with the object of arriving at a solution of the problem of providing proper ventilation for sewers. As in other cases, the usual conflicting and negative results were obtained, and ultimately the conclusion he arrived at was that it was not so much the disposal of the offensive gases which demanded attention as, first the determination, and then the removal of their specific causes.

Causes of Foul Smells.—Only after many years of statistical recording and personal observation did the causes become apparent, and having discovered these causes they were found to resolve themselves into three classes:

(1) Those brought about and kept in existence by some local defect, such as uneven invert, ridges formed inside pipes by jointing material adhering to them, insufficient flow, etc., all of which could be remedied by structural alterations, repairs, or special means of flushing.

(2) Those due to defective design, such as stagnation of flow caused by flat gradients, inequalities existing in old, worn-out sewers, which can only be remedied by reconstruction.

(3) Special causes which arise in connection with those main sewers which receive and convey the sewage from an outside district.

Dealing first with the local defects, which account for about one-half of the complaints usually received, the author has proved that one of the most prolific causes of foul smells is the breaking up of the solids carried in the sewage and the "churning up" of the latter. Probably every member present has at some time or other made use of that rough-and-ready method of detecting impurities even in clear brook-water by partly filling a tumbler, covering it with the hand, and, after shaking it up, applying it to the nose. To a great extent the same churning action takes place where, for special reasons (usually to save excavation), a sudden drop occurs in the sewer, or where a branch sewer is connected up to deeper one by means of a vertical drop-pipe.

As in many other towns, this arrangement was generally adopted in Birmingham, and had the effect of not only causing a nuisance in the immediate locality, but by the induced current of air the foul smells were driven to find an outlet at street openings situated perhaps hundreds of yards distant. Every case where this trouble was discovered was taken in hand, the drop-pipes removed, and easy ramps substituted, and it was astonishing to find how suddenly all complaints from residents in these localities ceased.

Another frequent source of trouble in connection with brick sewers is the practice of connecting up branch drains by means of stoneware junction blocks, so designed that they can only be built in the sewer at or about the springing of the arch. In consequence of this, excreta and filth, instead of passing direct into the flow, slide down the side walls, creating a foul deposit upon them. To get over this defect, the author has for many years discarded the ordinary junction block, and made use of specially made inlet pipes with splayed ends. These are made in four types, so designed that they can be built into different sized sewers at varying heights, so as to discharge each flush almost direct into the flow at its maximum dry-weather level, thus avoiding not only the breaking up of the solids, but also the fouling of the brickwork.

Turning now to those causes mentioned in the second class—viz., those due to defective design—the worst cases to deal with are those where bad gradients have been adopted, perhaps to save a few feet of excavation, the result being that the sewage, instead of moving forward, is held back. Apart from the silting which takes place, this stagnation of flow, particularly in the summer and autumn months, hastens decomposition, being frequently the direct cause of those foul smells which become less noticeable or even disappear entirely as the colder weather sets in and the temperature of the sewage falls.

As regards the special cause placed in the third class, many interesting cases of this kind have occurred in the author's experience. One in particular he recalls, in which for many years complaints were continually received from the residents in a certain locality adjoining the boundary of a large borough. The sewers were first carefully examined for structural defects, but nothing could be found to account for the trouble; the gradients of both main and branch sewers were excellent and the depth of flow considerable. The fact, however, remained that the sewage itself was in an exceptionally foul condition. Some years later when the borough referred to was able to exercise some control of the sewerage of the outside district, the mystery was solved, for one of the incoming main sewers had not received any attention for years, and was found to be almost choked with filth—in fact the sewage was being sent into the main sewerage system in a totally unfit and septic condition.

Remedial Measures.—The point now is how to deal with the foregoing conditions; obviously the first step is to remove the local defects, such as vertical drop pipes and junction blocks fixed in wrong positions. The benchings of manholes should then be examined, and if found to retain filth they should be raised so as to be clear of the flow even in flood times All useless ironwork, such as flushing gates, penstock frames, and other obstructions to the flow should be removed, and, lastly, the drains on private property should be tested with hose-pipes, so as to ascertain which are running free or which are blocked or partially blocked. Where sewers are laid to bad gradients, so that constant cleansing is necessary, the author has always held the view that it is entirely wrong to be continually bringing filthy refuse to the surface at a cost of about 20c per cubic yard (pre-war price), keeping perhaps a special gang of men employed under conditions more irksome and disagreeable than any other kind of manual labor. The Public Works Committee of Birmingham has for the past 20 years recognized this, and instead of erecting ventilating columns or otherwise cloaking the evil, have boldly adopted the wise policy of having such defective sewers reconstructed.

As regards dealing with the sewage discharged in a septic condition from an outside district, this is a difficult and also delicate matter, but the proper solution undoubtedly is that under any arrangement made powers should be given to the authority which may be prejudicially affected, to insist that the contributory sewers in the outer district are kept in a proper and sanitary condition, and that they should also have the power to periodically inspect these sewers so as to satisfy themselves that this condition is being complied with. Failing such power, the only alternative is to close down all offending openings, and erect ventilating shafts so as to discharge the foul smells well away from the buildings.

From the previous remarks it will already have been gathered that the author does not favor, except as a last resource, the use of ventilating columns, sewer gas destructors, and chemical deodorants, which after all merely cloak the evil instead of striking at the root cause.

Unfortunately, one of the main difficulties occurring in nearly every sewerage system is the lack of flushing power at the upper end of each branch sewer, the solid matter being retained frequently for hours before reaching a point where the flow is sufficient to carry it away in a proper manner.

Here again it is not a question of sewer ventilation, the trouble being merely local and quite remediable by flushing. To a certain extent the difficulty has been overcome in this city by organizing special flushing arrangements, the main and branch sewers being periodically flushed by means of 500-gal. horse-drawn vans, while the back sewers on private property were dealt with twice yearly by several small gangs, each equipped with the necessary lengths of hose-pipes, etc.

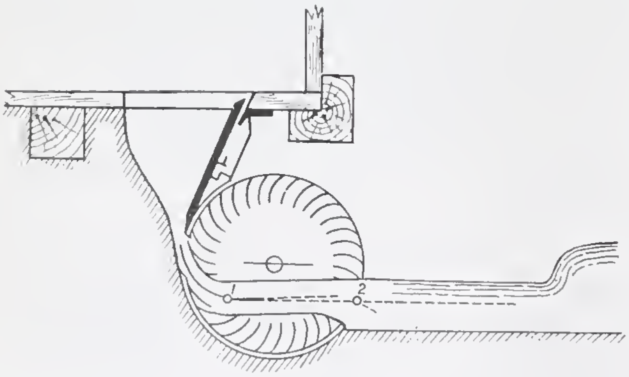
The flushing was carried out systematically by scheduling every dead end on the main and branch sewers so that it received on fixed days in the week one, or in special cases two flushes. Under this system the sewer inspector knew at any time where each flushing van or gang was at work, and it enabled him to efficiently control the operations. During the spring and winter these weekly flushes were quite sufficient, but as the warmer weather approached the number of complaints increased rapidly. Even bi-weekly flushes did not greatly improve matters, pipe sewers which had only been laid a few years, and having good gradients, being even more offensive than some of the old brick ones. Careful investigations, however, generally proved that in most instances the trouble was not due to any structural defect, but simply the fact that the flow was insufficient. As a remedy, therefore, ventilation again only hides the evil, the proper cure being to provide proper flushing. By this the author does not mean the still more frequent discharges from a 500-gal. van, but much smaller flushes of, say, 40 to 50 gal., discharged twice or even three times in the 24 hours by means of automatic siphons or tipping tanks.

Unfortunately, the hands of the municipal engineer are tied when he comes to apply this principle on a large scale at each "dead-end," the initial cost of each flushing chamber and siphon being considerable; but what probably prevents this system from being more generally adopted is the water bill which has to be met. Then there is the cost of carefully measuring through a meter every gallon of water used, together with the ever-recurring charges for repairing and keeping such meters in order, and, lastly, perhaps the most important item is the necessity to have on the engineering or mechanical staff an assistant possessing a sufficient knowledge of hydraulic principles that he can locate, and frequently in a few moments ascertain the cause of, and rectify the defects in the siphons without having to call in the maker each time a hitch in the working takes place.

Failing this, the common fate of these appliances appears to be that they work satisfactorily for a year or two, then fall into a state of disrepair, and ultimately are forgotten entirely.

New Water Turbine

A new water turbine designed to bridge the gap between the higher speed of the Pelton wheel and the lower specific speed of the Francis turbine has been devised by D. Banki of Budapest, according to Elektrot Maschinenbau of Dec. 29, 1918. It is stated that the new turbine can be installed as simply as a waterwheel and can be substituted for a waterwheel almost without structural alterations. It can be given the speed of the driven machine so as to eliminate gear transmission. Other advantages compared with waterwheel operations claimed for the new turbine are: low first cost, saving in space, higher efficiency, reduced operating and repair costs. The wheel consists of two disks carrying a series of cylindrical blades. The inlet is adjusted by hand, and the water imparts energy to the wheel both at entry and when it passes through the blades a second time at exit. The diameter of the wheel is independent of the quantity of water; the breadth of the wheel is chosen to suit the latter. Water is led to the wheel at an agle of 16°. The outer blade angle is 30° and the inner blade angle 90°, so that in both places the water enters the wheel without shock. Tests with model wheels of the new type are claimed to have indicated efficiencies of 89 per cent and 87 per cent. The reason for the high efficiency of the wheel is to be found in the simple, almost loss-free passage of water through the blades. The kinetic energy of the outflowing water can be utilized to maintain an artificially lowered level at the turbine. The wheel may run partially submerged without appreciable loss of efficiency. Where the downstream level is very variable the turbine is built in an airtight casing and the water is taken away through a suction pipe. The new turbine is recommended specially for driving high-speed dynamos.



New Water Turbine Devised by D. Banki.

Reconstruction Problems of British Municipal Engineers

BY E. J. ELFORD,

Municipal Engineer, Cardiff.

From the Journal of the Institution of Municipal and County Engineers, London; abstract of a paper presented June 17, 1919.

In every town the cost of public works has been rising by leaps and bounds, and there are few places where the taxes are not considerably higher than in pre-war days. This is very largely the result of higher wages, but there are also other causes, such as unreasonable profits. Before the war the wage of unskilled laborers in Cardiff was 6½d (13 ct.) per hour, and the ordinary working week was 52 hours. Now the minimum rate is 1s 3d (30 ct.) per hour for a 47-hour week. Personally, the writer is not afraid of high wages and short hours, if men will do their best while at work with both hands and head.

History has shown that increased cost of labor has invariably stimulated invention, which has often had the effect of ultimately reducing the cost of production, notwithstanding the higher rate of wages. To some it may appear that progress in this direction is nearly exhausted, but the writer is optimistic enough to look for the invention of appliances and the introduction of methods for increasing the productiveness of human effort to a greater extent than any which have been produced in the past.

The same considerations apply in a greater or less degree to practically all branches of work, and there is probably not one which would not benefit by thorough study and research on scientific lines. Certainly the various activities in which municipal engineers are engaged would be no exceptions in this respect. At the time war broke out a move was being made in the direction of the greater use of labor saving appliances for municipal work. War demands of the past five years practically put an end to this for the time being, but the conditions now operating are such as to render it more imperative than ever that every effort should be made to increase efficiency and reduce costs. The writer now proposes to suggest a few directions in which it should be possible to do this.

One of the most important, and, at the same time, most costly duties of a local authority is the collection and disposal of house refuse. In many cases the collection can be very much cheapened by the extended use of mechanical traction. In employing vehicles driven by steam or petrol engines, one of the main essentials to efficient working is to secure a reasonable daily mileage, and this is almost impossible when they are used in the ordinary way for house to house collection. The mileage factor must necessarily be small, which means intermittent working. In addition, the constant starting and stopping also reduce the efficiency. Electrically driven vehicles, however, are not affected to the same extent by these conditions, as energy is being consumed only when the vehicle is on the move, and in almost direct proportion to the work done. Moreover, they are simpler in construction and operation, and, consequently, less liable to get out of order, and can be managed by comparatively unskilled men. Under most conditions, therefore, where a self-contained motor vehicle is used for this class of work, the electric lorry appears to be the most efficient.

The writer suggests, however, that in many towns, especially where the dump is a considerable distance from the point of collection, it would pay to collect from house to house by horses and arrange for the delivery of empty wagons and picking up and haulage to the tip of full wagons by small tractors. Such a system would require careful organization and supervision to prevent waste of time at the change-over points, but, from an experiment he made just before the war, he is satisfied that it has great possibilities. Wagon bodies which can be loaded from ground level would also reduce labor considerably. The writer is aware of the practical difficulties of doing this, but does not think they should be found insurmountable. If they are, he suggests the consideration of some simple form of loading apparatus attached to motor vehicles, so that the refuse could be tipped into a hopper from the road and loaded by mechanical power into the vehicle. Many motors used for municipal work are fitted with interchangeable bodies, but the methods adopted for changing over are often such as to involve much waste of time and labor. It is important that this should be prevented.

It is recognized that to obtain the best results from the use of motor vehicles, quicker loading and unloading must be provided. A power tipping body will give the latter, but quick loading is more difficult to arrange. To load a 5-ton lorry with macadam by hand would take three men, on the average about ½ hour, and assuming, say, four loads a day, means a cost for labor of probably 2s (48 ct.) a load, even if the men can be kept fully employed between the loads, which is seldom possible, and a loss of at least a load a day. The writer is considering the provision of a simple portable elevator, in the hope that it may be possible to load a lorry in about five minutes.

Petrol motor sweeping machines are in use in a number of towns, and enable the carriageways to be cleaned more quickly and more economically than by horse-drawn machines. Efforts have been made to produce combined sweeping and collecting power-driven vehicles. The writer has been able to inspect several types of these machines, but has not yet seen one that appears to him to be fully satisfactory. They may be divided into two groups, viz., those which sweep and load into a separate vehicle, and those which sweep and load into a container forming part of the machine itself. Both types appear to be cumbersome and clumsy, and neither is capable of sweeping close up to the curb, where most of the dust accumulates. The latter type of machine involves a journey to dump each time the container is filled, and, as the capacity of this must necessarily be comparatively small, this is likely to result in much loss of time. Another disadvantage is that such a machine can be used for no other purpose, and would, therefore, be idle much of its time.

The ideal apparatus would seem to be a light portable combined sweeper and elevator, capable of sweeping right up to the curb, and delivering into a separate vehicle, either motor-driven or horse-drawn. It might be desirable to make the apparatus self-contained by providing it with a small petrol motor for operating the broom and elevator. Hitherto, machines of this kind have had to rely for power upon the vehicle receiving the refuse, the power being transmitted through the road wheels. The writer suggests that, where the mileage of roads to be swept is considerable, the most economical course would be to sweep the refuse from the road into the channel by motor-driven sweepers and then pick it up and load it by means of the suggested combined sweeper and elevator. A machine of the latter kind might be so constructed as to permit of the removal of the sweeping apparatus, so that the elevator might be used for other kinds of work.

Vacuum gulley cleaners are already used in large numbers, and effect a considerable saving in labor and expense where the street gullies are of a suitable pattern. During the war street watering has been reduced almost to a vanishing point, and, although it is desirable in the interests of public health that this should not continue, it is not likely to be carried out to the same extent as before the war. The introduction of road tarring, and of impervious road surfaces has done much to reduce the dust nuisance, but it must be borne in mind that the dust now produced consists largely of decomposed organic matter which is particularly dangerous to health. The flushing the channels and branches to a width of, say, 2 or 3 ft. from the curb, is of much advantage from this point of view, and can be carried out quickly and economically by electric or other motor water vans fitted with side distributors.

Local authorities who execute much of this work by administration will, in most cases, find it of advantage to centralize the work of their various departments, and to provide or increase labor saving appliances, such as power-driven circular and band saws, lathes, drilling machines, smiths' hammers, chaff-cutters, planing machines, hoisting apparatus, etc.

Where natural stone paving is used in large quantities, it may be worth while to consider the installation of pneumatic stone dressers, and, in some cases, such as tramway works, a pneumatic tamping machine may be found advantageous.

Under present conditions it is not sufficient that members of the institution should be content to rely upon manufacturers to introduce improved apparatus, but they should endeavor to think things out for themselves, and devise new and improved methods.

The subject of street construction is also one which must be reviewed from new standpoints. The cost of wood paving is almost prohibitive. Granite setts are also high in price, but less costly than wood. The ordinary rough setts are, however, objectionable, being both noisy and destructive of rolling stock and horses. Although it is impossible to estimate the loss to the community resulting from this destructive effect, it is without a doubt a very serious item in towns where setts are in general use. The writer suggests that this is a question which should not be overlooked by local authorities and that all such matters should be viewed from the standpoint of what is best for the community as a whole. If this attitude is adopted it will also mean that local, or at any rate, home produced materials will be used so far as practicable. It is partly for this reason that the writer has been seriously considering the adoption of concrete roads, and he has come to the conclusion that, given great care in the selection of materials and the execution of the work, they are likely to prove satisfactory and economical substitutes for wood, granite and asphalt paving.

The labor question, which has assumed a new aspect since the beginning of the war, is one with which the members of the institution are deeply concerned. In dealing with this matter, tact, sympathy, an unprejudiced mind, common sense, and, above all, absolute good faith are necessary. It is generally agreed that the great obstacle to industrial peace and national prosperity is the atmosphere of distrust and suspicion which appears so general at the present time, and it is a patriotic duty of the members of this institution to do all in their power to restore mutual confidence. This is probably, after all, the most important and difficult national problem now awaiting solution, and is worthy of our best efforts.

Technical Men of Germany Form Union

Step were taken last year to bring about a union of technical men in Germany. The first general meeting was held in Berlin on Nov. 25, some 2,000 engineers, architects and other technical men being in attendance. On Dec. 2 representatives of all the larger technical societies of Greater Berlin agreed on the necessity for the formation of the union and on the correctness of its aims. The purposes of the union are set forth in a report, a translation of which appeared last September in an English Commercial journal. The objects of the union, according to this report, are:

To ensure that technologists may bring their influence to bear on government, parliament, and the economic life of the country.

To attain this object it will use every endeavor to bring the representatives of all branches of technical practice, from the foreman to the technical chief, into one comprehensive organization.

The program of the union will be based on the foundations of a free, democratic constitution.

The union desires the active collaboration of its members in public life. In order to realize this program, the union will (a) insure its members a more clear comprehension of the conditions under which the people live, of national life, of legal machinery, administration, economy, politics, and cultural matters, with special reference to the systematic training of members capable of acting as the representatives of technology on public bodies. (b) Explain to other circles of society the importance of technical work for the life of the people and the maintenance of civilization at the proper level of culture, and the necessity of leaving technical questions to be settled by technical men only.

The union repudiates any unconstitutional attitude towards other circles of the population, and will use every endeavor to secure intelligent co-operation, based on trust and respect, with the working classes.

The union declares it as necessary for securing its objects that its activities should provide means for an adequate existence for every one belonging to the technical trades or professions, in order that he may work independently of his own or outside support.

The declaration containing this and other resolutions was signed, among others, by representatives of: Committee of Technical Officials of the Ministry of Marine, Society of Architects, Automobile and Aeronautical Society, Society of German Engineers, Society of German Civil Engineers, German Technical Society, German Union of Technologists, Electro-Technical Society, Society of Naval Architects, Union of Academical Architects' Societies, Union of German Electrical Engineers, Society of German Patent Agents, Society of Surveyors, German Chemical Society, German Foundrymen's Society, Society of German Mechanical Engineers.

Standardization of Structural Steelwork

By R. B. REID.

From Journal of Steel Structural Section of the British Engineers' Association.

At first sight it would appear that constructional steelwork is not a promising field for standardization. The engineering and other requirements are so varied and the ground covered so extensive, that there leaps at once to the mind the wide range over which the activities of the constructional engineer extends.

The benefits to be derived by the purchaser by the application of standardization to structural steelwork, where it is practicable, will be readily appreciated. The interchangeability of a multiplying member or element in design would result in simplification of construction, making possible, improvements in methods of manufacture, in rate of production, output, and erection, and a reduction of waste and inefficiency. Individual jobs would be transformed largely into aggregate production, and there would be a leveling up of the output curve by making use of the latent capacity of plant and organization which runs to waste in the "dry spells" and is overworked in the "spates."

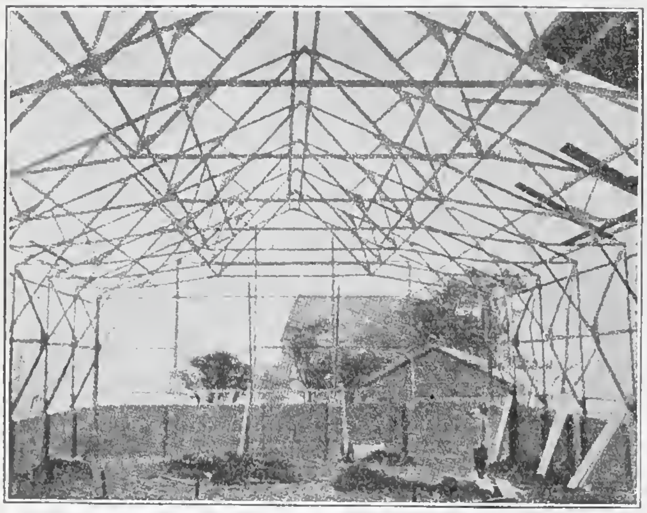


Fig. 1—Standardized Construction As Applied to Pattern Store Building.

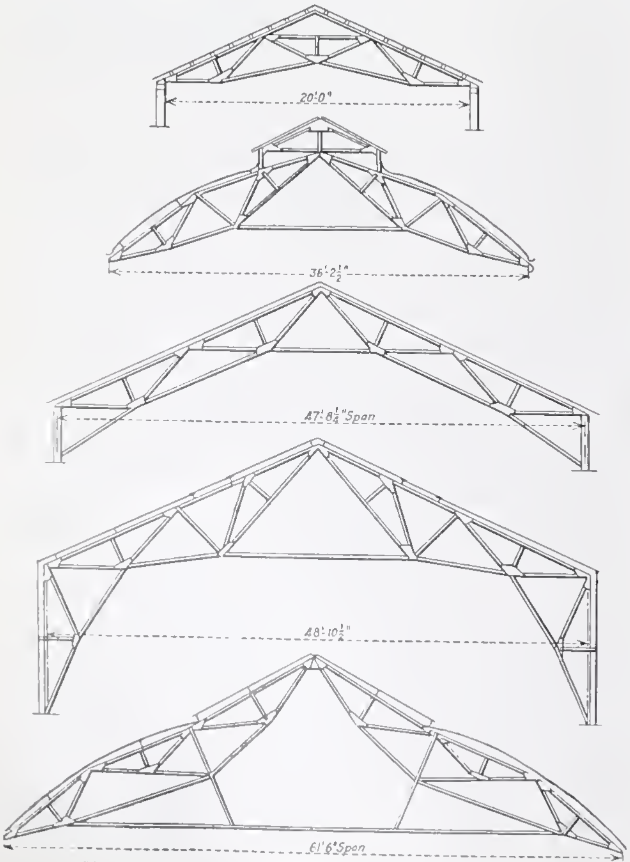


Fig. 2—Types of Standard Unit Roof Trusses.

The illustrations show a successful method of standardized construction as applied to the range of steel construction required in industrial buildings such as stores, workships, roof trusses, girders, etc.

The essential features of standardization are:

1. Repeating standard units, or elements of a convenient form, and of the simplest form possible.
2. Limitation of number of different sections or parts used.
3. The adoption of common sections easily obtainable.
4. Adaptability to various strengths, forms, and dimensions as required in construction, making the range of application as wide as possible.

The illustrations in Fig. 2, showing a few types of "standard" trusses as constructed, indicate a fairly wide rauge of application. Variations in strength are provided for by doubling all or any of the sides of triangular unit and bar.

Illustration No. 5 shows an interesting case where the conditions were as follows:

The work was to extend an existing curved roof having a rigid skylight. The arrangement of the standard units gave chords on the actual curve of existing rafter (shown dotted) and the purlins were fixed to exact surface of sheeting curve by light strap supports fixed to standard holes. There was an adjoining curved span of the same type 56 ft. span which was treated successfully by a similar arrangement of the standard materials.

In Fig. 1 is shown a type of building used as a pattern store, where side uprights were of standard units and bars. The framing in this case was of timber for purlins and side rails. This type of knee braced frame has the additional advantage of reducing the stresses brought on foundations, by eliminating bending moment at the column base, and so relieving the foundations, which are then only required to be of sufficient area to resist direct loads.

As there are certain features in design involved by the necessity of the standardization of interchangeable units which form a departure from usual design, this unit construction was subjected to a series of tests under varied conditions of loading which successfully proved its reliablity for the field of construction to which it is applicable.

In conclusion it may be said that there is a considerable field for the operation of the ingenuity of the structural engineer in the improvement, simplification, and standardization of details and elements in construction.

Shaft Sinking Record.—The following details regarding shaft sinking, in December, 1918, at the Crown Mines in South Africa, are abstracted from a paper read a few months ago at a meeting of the South African Institution of Civil Engineers, by Mr. H. Stuart Martin: Diameter, 21 ft. 6 in. (20 ft. in the clear): During 31 days, 279 ft. were sunk. Costs taken over 30 days (270 ft.) totalled 13l. 4s. 8d. ($64) per foot. These costs include the whole of the station cost—walling only excluded. The average tons hoisted per blast was 90, making 8,100 tons for 30 sinking days, three blasts per day. Average of 31 natives per shift in shaft per day, or 93. White men in shaft: Leading hand sinker, 1 per shift, 3 per day; second hand sinker, 1 per shift, 3 per day; stagemen, 1 per day; master sinker, 1 per day. Total in shaft per day, 8. Total other whites employed on surface: Engine drivers, 3; boilermen, fitter blacksmith, machine men and masons, workshops, etc., 9; grand total, 20. The total explosives used amounted to 15 lb. per foot sunk. Machines: Four Holman torpedo sinkers; two Holman jack hammers. A depth of 279 ft. sunk in 31 days constituted then the world's record for speed in sinking, covering all forms of shaft. This shaft-sinking record has again been broken at the same shaft, the footage accomplished for the month of July, viz., 31 days, being 310 ft. The total tonnage of rock hoisted for the 31 days amounted to 10,134 tons. This work was carried out under the supervision of Mr. Ivor Rees. In this last instance also the rock drills used were the Holman sinker and Holman hand hammer.

Concrete Ship Faith Crosses Atlantic.—The London Morning Post reports that on Sept. 11 members of the Concrete Institute inspected the concrete ship Faith which had just completed a voyage across the Atlantic.

Collection and Disposal of Refuse

By F. W. BROOKMAN,
Cleansing Superintendent, Rochdale.

From The Surveyor, July 11, 1919.

Petrol trucks, in spite of the cost and difficulty in obtaining petrol, have been a great help during the war, and I want to suggest that as the cost of the wagons gets easier and the petrol becomes more plentiful the home-manufactured benzol should be used either alone or mixed with petrol. For all users of petrol vehicles it would be a good thing, if there were inspectors on the road to send home all badly-running vehicles, and if the truck was taken in hand at the first warning there would be many less breakages.

The Choice of Trucks.—It is not always easy to decide what size of truck is the best to adopt, but where its work is more or less of a certain type, or, shall we say, suppose a truck is to work nine-tenths of its time on one job, naturally that job should rule the size, and it should always be remembered that a 6-ton truck costs no more in labor to run than a 4-ton does, and there is less time taking per ton at each end of the journey getting into position and also in loading and unloading.

The electric truck has been much to the fore during the war, and could they have been obtained there is no doubt that they would have been in evidence almost everywhere. Where they have been adopted for comparatively level work I have heard them well spoken of, but in cases where the roads are other than level this has not always been the case. This does not by any means condemn the electric truck, but only shows that sufficient care has not been exercised in purchasing the truck, or that the makers may have been so eager to sell that they have sold a less power truck than was warranted for the work in view, and that both buyer aud seller be to blame. Of course, this also obtains with petrol trucks, and a truck is purchased for 30 cwt. load and often works to 2 tons and trouble soon results. To my mind the electric truck is a most economical wagon to run if of a sufficiently powerful type, without it being necessary to undermine its constitution by want of energy.

Horse Transport.—Owing to the high price of horses and provender it is now a question as to just where the dividing line should come in. This must depend on the district, for in one case it may pay better to work a horse in a four-wheeler as far out as a mile, while in another case half a mile might be over the mark. Now that the 48 hours is the limit, the horse journeys may be so shortened that the old number of journeys can be done, and the quicker-moving motor trucks put on all outside the horse area. In this outside area you can use either a moderately-sized truck or a truck about half the size and holding about the same as a horse four-wheeler. Suppose, however, you put on a large truck and put all the men on it that you would put on to three small ones, your result would be nothing like the same. You might possibly not get done more than half what the three small trucks would do because of the distance the large trucks would have to travel to get a load, and the unwieldy character of the machine in small areas.

Tipping and Loading.—As to tipping trucks, the tipping arrangements should be of the simplest possible character. The experiment has been repeatedly tried on two trucks—one a tipper and the other a non-tipper—of moving the same material from and to the same place, and the non-tipper could easily beat the tipper owing to the character of the tipping arrangements.

Whenever possible the vehicle should be such as to be readily loaded by a man on the pavement without the use of a ladder. Trucks of the type used at Bury are easily loaded and tipped, and it is not difficult to get comparatively low-bodied trucks of other types to fill this requirement, and recently I have seen steam trucks that could easily be loaded over the side and at the same time give a passable tip. These trucks will carry up to 5 tons in weight and run well on coke breeze, with which a cleansing department could easily supply itself from the refuse.

The Position of Ash Bins.—In connection with refuse collection, another point requires constant attention. In many districts now a wagon could be loaded in half the time at least, if the ash bin or ash place were accessible from the passage without having to go the length of the garden or yard, not to mention locked yards. I think the position of the ash bin is an important item on a building plan, and that it should be put in the most getable position. In the case of old property it would be time well spent in many cases when any alterations or repairs are being executed, whether to the ash-places or not, to talk the matter over with the landlord and point out to him not only the advantages that an alteration in the site of the ashplace or bin would be to us, but also how such an alteration would benefit him and his tenants. It is no uncommon thing for a load in one particular district to take as long as two loads in a better arranged part of the town.

Another point that tends to waste time is where dwellings have their own particular utensils for containing ashes and refuse, in which case every particular bin or tub has to be carried back again after being emptied into the cart or wagon. In some cases the refuse must be carried from the back round the end of the house to the front and the length of the front garden or lawn into the front street. These are the places that waste time, get the men out of sight, and cause trouble all round.

Sometimes we do see something quite contrary to the time-wasting process above mentioned, and I shall never forget a little performance I once saw in the collection of refuse.

I had appeared on the scene quite without notice, and in the absence of the local superintendent. The ash bins (all galvanized) were previously deposited along the curbstone edge by the tenants, and while the motor truck traveled up the center of the street the ashmen simply hoisted up the bins on to the truck (without it stopping) and the man in the truck picked up the empty bin and dropped it over the side into the hands of the man who brought it.

Disposal of Refuse.—In a few towns the pail contents are dried and thus made into a valuable manure, for the mere act of drying (along with a little acid) can under certain conditions increase the percentage of ammonia up to 12 per cent, which makes it work out about half as much as sulphate of ammonia for this item alone, and there is also present certain phosphates, potash, etc., so that it is a good all-round manure. The production will continue until the pails are replaced by water carriage, when we shall look to the sewage works to have produced a good substitnte, and they will have no little problem in that the town manure will be intermixed and partly dissolved in millions of gallons of water.

With reference to the ash refuse we are not much nearer a good solution. In pre-war times it was almost the unanimous opinion that the refuse should be burnt so as to get rid of the putrefactive or organic matter and to make an innocuous clinker that could be used for many purposes, or tipped anywhere without being detrimental to health. While the matter of cost was at that time fairly heavy, both in collection and burning, it was low compared to what it is now. Given that we shall eventually exterminate the pail closet, there is no chance of eliminating the ashes collection, for while it is possible in certain factories and manufacturing premises to establish suction conduits to carry off the dust, sawdust, shavings, shoddy, etc., it would be quite a different problem to instal a system to draw away to the depot or the tip the ashes refuse of a town, intermingled with the pots and pans, tins, broken bricks, etc.

Recently there have been put down screenings and washing plants for screening out of the refuse the cinders and washing them so as to recover this valuable fuel. This, of course, separates out the inert fine ash—a material in itself which cannot be burnt, and which acts as a drag on the burning of the better fuel. Further, this is taken out at the first handling, and thus is not left either to be matted up against the clinker in the destructor and afterwards laboriously withdrawn and deposited on the clinker bank, or to be as laboriously riddled through the destructor grate if the stoker is sufficiently energetic so to dispose of it. In my opinion the screening of the refuse as a much better proposition than grinding up the whole of the material, good and bad, for it does enable you to use the good fuel, which, in its turn, may be used as fine ashes later, the inert fine ash is thus eliminated from the good fuel, which is then washed to dispose of adherent damp ash, etc. Where the fuel is to be used for steam raising (or like purposes) on the premises, the washing may be dispensed with and the plant simplified; but this must, of course, be left to local requirements. In some particular cases it may suit the conditions to get all the fine ashes possible, but I wish to point out that the material that will not pass through a ¼-in. screen is not the same class as that which will go through it; and even if you grind it the composition remains what it was before, and unless you want the material purely as an absorbent or as a mechanical lightener of clay land, you may have had your labor for nothing. Supposing, however, you ground the clinker to a fine powder you would render the lime contained in it available for agricultural purposes, and (depending upon the kind of coal used in a particular district) it would act on the land in exactly the same way as the lime in sewage sludge does, but it would save the carriage of the water in the latter and be much easier to spread and to work in. The availability of the lime for this purpose would depend upon its fine grinding, just as it will be remembered the now much-valued basic slag many years ago failed for want of proper milling.

The Competitive Contract System

By PAUL WATERHOUSE.

From the Journal of the Society of Architects.

The house which we have to put in order for the great post-war era into which we are advancing, is the great home of the art and craft of building. That house is full of appliances and every one of these appliances, from the driving wheels to the meanest cogs, should be considered well before it is cleaned and lubricated and put into fresh use.

It seems a fine thing to sweep away the system of competitive tendering. The faults of the system are so obvious. We set contractors to run a race not of excellence but of money. We say to them "come and struggle together for the prize of a job; the prize will be given not to the best builder among you, but to the cheapest builder, or rather to the cheapest estimator." We seem to be implying that neither we as architects, nor employers as owners, care how the work is carried out so long as it is got through at rock bottom price. It might be said that we were by such a system only making trouble for ourselves. For the cheapest man—the winner— is, it may be urged, the least likely of all the competitors to be able to put into his work that extra margin of quality which makes and marks the difference between a good building and a bad one. I think that if we architects were left to ourselves and to our own inclinations we should to a man give our vote for the abolition of competitive tenders. Don't we know the luxury of working through a building enterprise with one of those old friends in the building world whom most of us middle-aged architects are happy to possess? Don't we know the pleasure of realizing that this old friend has been put in without competition on our own nomination, but with the perfect acquiescence of a trustful client who wants the best work out of both architect and builder? Must we not acknowledge that there is a pleasure about such work for client, architect, and builder, which is by no means always found in those undertakings whose birth is presided over by a sordid money struggle? We do, indeed, most gratefully admit that work under conditions such as these has often been our happiest and our best, and that though the contractor may have been paid a trifle above lowest rates the bargain between owner and builder has been a fair one and satisfactory to both parties.

But can we look upon such a system as the normal one; and would it be well for builders and employers if the competitive system were swept away? I believe not. The builder in the ideal case just described must be paid on a reckoning of some sort; and that reckoning must be made up and checked in one of two ways. It must either be on ordinary bill of quantities priced at the start, as if in competition, and adjusted by a quantity surveyor at completion or it must be a bill worked out on the prime cost and percentage system. (I do not regard the priced schedule system as a third method, for it is merely a variation of the priced quantities with the difference that the client gets no lump sum figure at the start.)

Now whichever of these schemes is adopted it is quite clear that unless confidence is to be carried to unusual and unreasonable bounds the builder's accounts have got to be checked by either an architect or a surveyor (or both) representing the owner. How is this checking to be done? The opinion of the surveyor as to the reasonableness of this or that price must be based upon some standard; and standards if they are fair can only be set up by some sort of competition. Competition exists in all healthy trades, and as builders cannot compete with one another by placing, like drapers and grocers, ready-made, priced products in a shop window, they must conduct their rivalry by giving competitive prices for certain objects, the identity of which is fixed by a specification and by quantities. I conclude, therefore that if for no other purpose than the establishing of an average of current costs, competition in price must continue to exist alongside of the continuation of that pleasanter method in which the builder is paid for his work without winning it on price. But there are other reasons also for the retention of the competitive tender, and perhaps the chief of them is that without it new and young firms would find it difficult to gain an entree into the building market; for the public having no price criterion to go on would perforce be inclined to choose their builders solely or mainly on grounds of well-established and long standing reputation. For many buildings in fact non-competitive payment is excellent, indeed advisable, but the abolition of competitive tenders or of competitive pricing on schedules would lead to random pricing, capricious increases of standard, disputes, and in fine to a state of uncertainty in which neither owner nor builder would be the gainer.

To suggest that the prime cost and percentage system of payment is the solution of all difficulties is misleading. It might be urged that the healthy competition between firms could be simply exercised by allowing them to quote against one another the percentage each is willing to accept on prime cost. But with every intention of honesty on everybody's part there is a difficulty in the very basis of the system. Prime cost! What is prime cost? I insult nobody when I point out that however loyal and honest a builder may be the prime cost and percentage system offers him no inducement to buy cheaply, and certainly encourages the builders' merchants to charge as highly as possible. If I were speaking with unguarded tongue I would suggest further that "prime cost," which sounds so final, is in the realities of commerce, elastic.

Features of Desrumaux System of Water Filtration

These rapid filters, constructed either of reinforced concrete or sheet iron, in the form of tanks, are characterized by the following arrangements:

(1) The solution of aluminum sulphate used as a purifier is distributed automatically and proportionally to the volume of water to be purified and clarified, quite irrespective of variations in the feed of the unpurified water or the consumption of filtered water.

(2) The proportion of aluminum sulphate can be modified at once, according to requirements, without in any way altering the concentration of the solution.

(3) The whole of the pipe system and cocks used for distributing the water to the filters, collecting the filtered water, and emptying the purging system, rests directly on the ground, and is therefore easily accessible.

(4) During the cleansing operation, the stream can be reversed instantaneously by simply opening the purge valve with which each filter is fitted, and this change in direction continues as long as the purging valve remains open. This operation, by allowing the filtered water to flow downwards under reduced pressure in the filter in operation, produces rapid filtering, without, however, carrying with it any of the filtering medium.

(5) No external force is required for operating the rakes in this new design of filter.

Advantages of Concrete-Wood Ships.—Concrete and Constructional Engineering, London, states, that according to a Norwegian patent granted in 1917 to Moe and Morch, the use of a combination of wood and concrete has the following advantages in shipbuilding: the vessel is lighter and cheaper to build, costly curved wooden planks and beams are avoided; the outer surface of the vessel is better protected than when wood alone is used and repairs can easily be executed. In the patentee's arrangement the skeleton of the vessel is of wood, the intervening saces being filled with mass concrete.

What the War Has Done for Engineers, and the Part Engineers Have to Play in Reconstruction

By COL. R. E. B. CROMPTON.

Abstract of Presidential Address Before the Junior Institution of Engineers.

The great event, the signing of the armistice, which must lead, we hope, to a peace which will endure forever, has determined me to attempt to supply answers to the two great questions which every engineer who listens to this address must already have put to himself: (1) What has the war done for us engineers? (2) What part have we to play in the vast work of world reconstruction? I think that the reply to the first question must be wholly satisfactory to you, that the war demands have greatly improved the status of the engineer in every department, whether it has been in the designing of new forms and of the organization of the manufacture of munitions, or their transport and utilization in the fighting line; in all of these the engineer has more than held his own.

In the past—in fact, ever since mankind divided itself into the two groups of those who work and those who talk—the talkers have had the upper hand and have always attempted to be the governing body. When we study the history of human progress, from prehistoric up to our own time, we cannot fail to note how completely the talker has taken the lead and has constituted himself the governing body, but rarely allying himself with the engineer worker, and then only when it suited his convenience, treating the engineer as an upper servant whose advice may be accepted or rejected as it supported or weakened the talker's position; and as the talker became more and more the representative of the status quo—i. e., of conservatism and reaction—so the engineer, the creator of new work and the natural leader of the workers, was thrown into a position of antagonism to the talkers.

One year of war showed that nine-tenths of the work was essentially the work of the engineer. In every department of Government engineers found themselves forced to the top, their advice eagerly taken, and in all the great departments of engineering the natural leaders of engineering took their proper position as administrative heads of departments.

I think that I may therefore answer the first question, that the status of engineers in regard to the body politic has reached a point which it would have taken many years to reach if it had not been for the war. The war has been the crucial test between the workers and the talkers, and here, at any rate, the workers have won.

When we turn to the second great question—What part have we engineers now to play in the vast work of world reconstruction?—I propose to call your attention to those branches of engineering work which will, I feel sure, first demand your earnest attention.

There is no branch of engineering which we can unhesitatingly say ought to be, and will be, fully employed during the next 50 years, which is so full of promise for the future comfort of mankind, as food production on a scientific scale, unless—and this brings me to the next great department of engineering—it is the transportation of the necessaries, food, clothing and housing, furniture and domestic equipment. Transportation always has been par excellence the domain of the engineer, and the war has shown us what lack of it really means.

I should be attempting too much to discuss with you the great scope for design and for your creative talent in the cheapening of ships. It is too evident for me to bring it specially to your notice. I prefer to dwell on land transport, a subject to which I have paid considerable attention.

I take, as first in order of importance, the future improvement of transport by road. Progress was retarded in the early part of last century by authorities allaying themselves with the vested interests. At the end of last century, with the advent of the motor car, this was changed, for the improved power-driven vehicles imperatively demanded improved road services, so that during the 10 years immediately preceding the war considerable progress had been made; the Government gave way to the demands of the vehicles, and the Road Board was established.

We hear on all sides that our roads have suffered terribly from the war; that the shortage of labor and restrictions on the use of road stone and other materials necessary for road repair have, combined with the extra traffic imposed by the war, resulted in the breaking up of the surfaces to such an extent that vast sums will be required to put them into a fit state to carry the increase of traffic which we all expect will follow during the reconstruction period. This pessimistic view of the matter requires to be corrected, for, as a matter of fact, the improved road surfaces which had been developed by the experimental work and the grants-in-aid made by the Road Board from the time that it came into being up to July, 1914, have stood remarkably well the severe strain of carrying the increased war traffic. The main roads of Kent, Surrey, and elsewhere, where the most improved surfaces have been laid down, are the best evidences of this. Take the main road from London to Folkstone as an instance. This road has been continuously traversed by long, heavily-laden trains of motor-wagons carrying war material, and yet, as I am informed by the County Surveyor of Kent, very little money has been spent on repairing its surface during the four years of the war. Moreover, he has pointed out, that in the open links—i. e., wherever it is not enclosed by houses—it has been practically self-cleansing by the natural rainfall. It is very fortunate that this is the case, for it is evident that if similar surfaces are put down in other parts of the country at least as good results can be obtained.

Modern reconstruction will not be limited to our main or principal roads, but means must be found to resurface all our roads wherever they approach dwelling houses, so that they may be free from mud in winter and be dustless in summer, for we now know that sanitation and the health of the children of our population demands this, for the dust that existed previous to our tarred roads contained harmful organisms which were the cause of many infantile diseases. This extension of the roads can only be carried out at reasonable first cost and annual maintenance, if adequate means are employed to sort the traffic—for you must understand that a cheaply constructed road will carry satisfactorily axle weighs up to 30 cwt. passing over it, at speeds up to 30 miles an hour, will be badly deformed and heavy repairs necessitated by few passages of heavier vehicles, if these heavier vehicles are driven at speeds exceeding 8 miles an hour. You must remember that the agent which deforms a road is the impact of the rolling wheels, which at high speed do not roll smoothly, but rebound and strike the surface rhythmically with a force proportionate to their weight multiplied in the square of the speed.

In our early efforts to produce strong road crusts which would be waterproof, we spread by hand and then rolled the stones which form the new coating, and then poured over it by hand from buckets provided with spreading nozzles a mixture of melted pitch and sand. This found its way into the spaces between the stones, and when the coating was firmly rolled, a surface was produced which we were well satisfied with at the time, as it was waterproof, and the stones were apparently sufficiently firmly held in place to resist the push effect of wheeled traffic. As time went on we found that roads so formed were far from perfect; they soon lost their level surface. Undulations or waves were formed, due to the stones themselves not being sufficiently closely packed together; in fact, the stones were actually spaced apart by the pitch and sand, which was in masses far too great for stability. In fact, the pitch and sand during hot weather softened and acted as a lubricant. It was seen that this effect would be reduced if the stones were more closely packed or wedged by smaller stones or chippings forced between them, so that the dry stone mosaic, before it was waterproofed by pitch being poured over it, could of itself resist the movement caused by wheels. Eventually one engineer, Mr. Drummond, of Paisley, perfected the method in the following very simple manner, a method of surfacing which deserves description. After the coating of dry sandstone has been once lightly rolled, Mr. Drummond spread over it some of the flaky chips which he obtains from his own stone-breaking works; then, by employing men to brush the chips from two sides—i. e., in opposed directions—the chips are made to stand on end vertically, their points resting in the spaces between the larger stones. If a large roller is then carefully passed over them the wedges are driven vertically downwards, the surface becomes immovable, and the spaces left between the individual stones and the wedges are so small, that when at this stage superheated pitch is poured over the surface, it fills the small spaces sufficiently to render them waterproof, but the masses of pitch are too small to yield and change form when softened by hot weather.

Now here we have a process which readily lends itself to the use of machinery, for even if it is found to be too difficult to spread by machinery the first coating of large stones, on account of the irregularity of the old surface which is to be resurfaced, surely it is not a difficult task for a designer to combine in one frame a first roller to level the newly-spread surface, with a means of dropping the chippings into place behind this first roller, followed by a means of pouring or spreading the melted pitch, and again followed by the roller which completes the surface. When I turn from the roads themselves to the vehicles which are to use them, I again put in the foreground the necessity of reducing the cost of labor—i. e., of the driver and assistants' wages as a proportion of the cost per ton of goods carried. It is evident that all the estimates of working costs which we had got together previous to the war must now be modified.

As our axle weights are limited by the strength of the road crust, it is evident that we cannot materially increase the net loads carried by a wagon and its trailer otherwise than by increasing the number of axles controlled by one driver and his assistants. We can do this to some extent by making our steering axles also to be load-carrying axles, to a further extent, by using three-axle vehicles, of which we shall be allowed to couple two together to take the place of the present wagon and trailer. But the method which promises greatest economy of labor charge would be that we should revive the train system introduced by Colonel Renard, in France, and which was also tried a few years before the war in this country.

As this matter possesses peculiar interest to me personally, I have gone rather closely into estimates of the saving that could be effected by using such road trains, if and when our Government extended the electric supply, now confined to our towns and a few districts, to the whole of our rural districts; which is a policy that has been put prominently forward in recent political speeches.

It is evident that if, and when, road vehicles can be driven by power derived from a side wire by a trolley pole, very great economy and tare weight of the propelling vehicles can be obtained, as the weight of the electric motor and its gearing is much less than that of the petrol motor, with its supply of petrol and cooling water, or in the case of the steam unit of the boiler and steam engine. It is probable, also, that the wages that must be paid to the driver and his assistant will approach closer to those paid to a tram driver than to those paid to the driver of a steam wagon or a 3-ton petrol-driven wagon.

Taking my most advanced idea, that it will be wise to develop the use of electrically-driven road trains, each train consisting of four three-axle vehicles, it would be possible to load each of these axles to eight tons, or a total moving weight of train close on 100 tons, without the road crust being stressed in excess of what is now the case when a motor wagon, with back axles loaded to eight tons, passes over it at the same speed. But I do not propose to avail myself of such extreme figures. I have, therefore, made an estimate of the working cost of a train consisting of four such vehicles, carrying a maximum full load of 32 tons, and, therefore, probably weighing under 60 tons. I have taken this average paying load at 16 tons; the annual mileage at 12,600, which is a double daily journey on 210 days of 30 miles out and 30 miles home. I therefore can usefully transport 200,000 net tons per mile per annum, and I estimate the cost of doing this at only £250 for electric power, £175 for drivers' and assistants' wages, which, with £1,000 for standing charges and for repairs, brings out the total cost at £425, equal to 1.51d. per net ton per mile, of which the wages charge is only .22d. per ton-mile. If I had taken the extreme axle weights I have just mentioned, of course my cost per ton-mile would be still lower.

Before I leave the question of multiple axle vehicles, I wish to declare to you that there is strong evidence that the use of three-axle vehicles is to be encouraged from the road maintenance point of view, as it has been shown that three-axle vehicles used on the road tend to reduce the height of the waves caused by the passage of two-axle vehicles.

I cannot approach the subject of railway reconstruction without referring to the proposals of Gattie to establish clearing houses in London and at other large railway centers, so as to reduce the number of goods wagons required for the transport of goods by loading their contents into containers, in which goods can be transferred without breaking bulk in the containers themselves. I, looking at it from the road user's point of view, am not wholly satisfied that Gattie's large containers, which occupy most of the space on the wagon floors, will greatly facilitate the distribution of goods, whenever these have to be carried partly by rail, partly by road. Now it is rarely the case that goods are loaded direct on to rail; they are generally sent either in the producers' wagons to the railway company, or collected by the railway company's road wagons, and transferred from them to the railway wagon, and again, at the end of the railway journey, transferred to the road wagon for further distribution.

I should propose to reduce the huge cost of these double terminal transfers by my transfer system. I hereafter give the name of "transfer" to a motor-box or frame, which is of a size so that it can be placed transversely on our railway goods wagons; can be loaded on to them by being pushed on to them from the side; and similarly unloaded at any convenient point on a railway by being pushed sideways from the railway wagon on to the road wagon. If and when my transfers are worked out so that their use becomes universal or nearly so, it will be unnecessary for railway companies any longer to shunt wagons for the purpose of unloading. Of course, there are cases where the goods—coal, ore, minerals, timber, heavy castings, or other bulky objects—take up the whole of a railway wagon; these must be shunted to be unloaded on a branch line; but my desire is that my transfers shall be capable of being unloaded by stopping the goods train at any desired point on the main line which carries goods traffic (such points being protected by signal in the usual manner). At these points, instead of the usual roadside station, with its sidings, goods sheds, and the like, it will only be necessary to provide platforms of a suitable height by which the road wagon can approach the railway wagon sufficiently closely to allow the loads to be moved from railway to road wagon or vice versa. I believe that it will not be beyond the skill of our engineers to design these railway wagon frames and the means of carrying the transfers, so that the process of transfer need not exceed one-twentieth of the time now required for shunting, detention in the station sidings for unloading the railway wagon reloading it, or dispatching it empty. My wagons, of course, could utilize Gattie's proposed clearing-houses, but, as far as I have been able to study his system, he does not give the facilities that I propose to give for the through distribution of goods from producer to user.

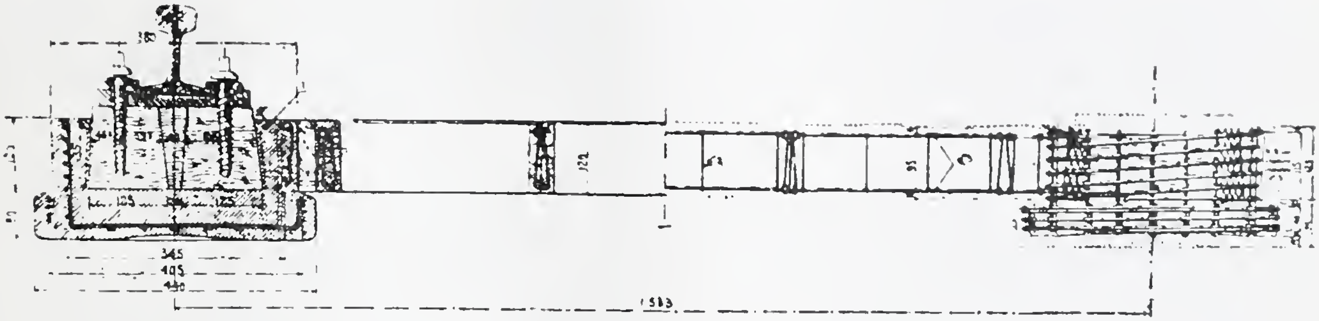
It is most desirable that the total carrying interests of the railway company and of the road vehicle owner (whether this be a private person or a great road-carrying company) should be one, and that there should not be competition. My transfers would effect this; the transfers themselves might either be the property of the railway company or of the road-carrying companies. It is evident that it would be in the interests of the railway to minimize the number of wagons it requires for its traffic by increasing the number of transfers, so that in all probability it would be better that the transfers should belong to and be considered part of the railway wagon.

Carrying Capacity of Cardiff Water Mains Reduced by Incrustation.—Incrustation of the supply mains of the Cardiff, Wales, waterworks has reduced their carrying capacity about 40 per cent, according to a paper presented recently by C. H. Priestley, engineer of the works. The pipe line was laid in 1886 and was capable at that time of carrying 11,000,000 to 11,500,000 gal. per day. At present the delivering capacity is 7,000,000 gal.

Reinforced Concrete Ties of Italian State Railways

From Il Cemento.

In considering the direction and intensity of strains it is well to recall the remark made by the Railway Engineers' Commission, presided over by F. Benedetti, to the effect that, on the passage of a train over a tie, the latter only receives a part of the load itself, as the neighboring ties contribute to bearing it. The fraction of the load which must be considered as bearing on one tie varies according to the distance between the ties, the rigidity of the reinforcement, and the distance between the wheels of the locómotive, cars, etc. Calculations have shown that the maximum bending movement to which the ties can be exposed when the maximum weight of the moving load is 17 tons could be calculated at about 150 ton inches, but such a result cannot be considered as being strictly correct, as the supposition of a continual loading of the ties on the bed is not always realized.



Half Longitudinal Section. Fig. 1. Half Plan of the Reinforcement.

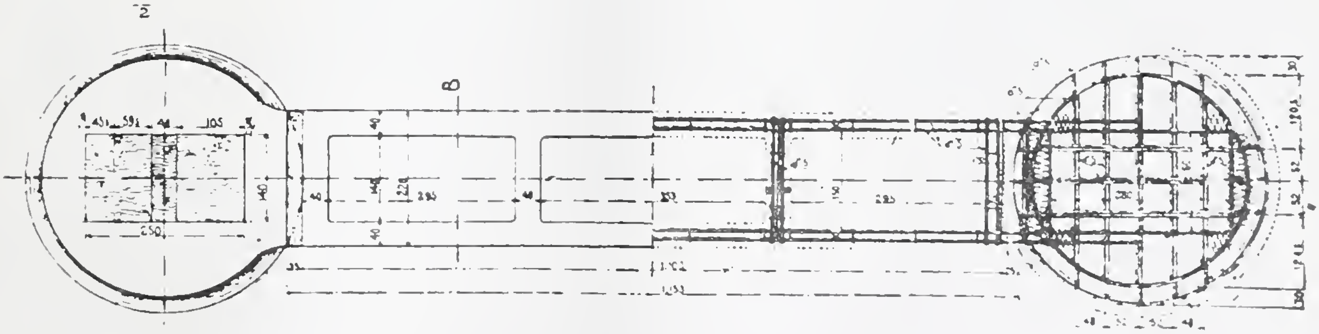


Fig. 2.

Half Horizontal Section. Half Section Showing the Reinforcement.

On the other hand, as a timber tie of ordinary dimensions satisfactorily resists the strain and pressure to which it was exposed, it was thought advisable to be guided by the resistance of such a tie when calculating the bending load and breaking strength of the proposed ties.

To equal an oak tie of the ordinary dimensions used on the Italian Railways, namely, 10 in. by 5½ in., with an average breaking strain of 8,400 lb. per square inch it is easy to calculate that for the reinforced concrete tie of equal dimensions the initial reinforcement should have a section of one-tenth of the total section of the concrete, i. e., there should be a quantity of reinforcement which is practically inadmissible for resisting such a moment, while if the reinforcement were contained within narrower limits and were made, for instance, of ½ in. round iron the maximum strain which the tie would withstand would be 8,000 lb. per square inch for the concrete and 140,000 lb. per square inch for the iron. In such a tie there would be nearly double the weight of reinforcement which could be practically allowed in order that the cost should not be excessive, and even then the strains would be nearly treble those which may cause the breaking of the reinforced concrete tie, considering such limits for the concrete to be about 2,800 lb. per square inch.

From the foregoing conclusions it was concluded that a reinforced concrete tie of the same shape and dimensions as the wooden ones could not be as strong as the latter, and that it was therefore advisable to consider new shapes for concrete ties, so as to reduce within the narrower limits the bending moments which affect the ordinary ties.

The new type of tie shown in the accompanying illustration is formed of three distinct parts, viz., two ends or bearings and the bars connecting them together. Each bearing is a cylinder which stands on a base of the same shape but of larger diameter; the connecting bars are formed of two parallel ties joined together and of the same height as the upper parts of the bearings and placed to correspond with them, so as to be at the same height above the ground level as the width of the lower cylinders and thus miss the footboards and other projections during the passage of trains. In the upper part of the bearing is an opening in which the apparatus for attaching to the rails is placed, consisting of three cones adherent to each other, their heads projecting above the heads of the bearing and constituting the supporting surface of the bearing plate. This arrangement prevents any contact of this plate with the concrete of the bearing, and therefore eliminates any risk of abrading or grinding away of the concrete. The plugs of the plates are screwed to the two outside cones of each bearing in the proper position according to the type of plate and the gauge. A preliminary lot of 100 ties was made from July 1st, 1916, to Sept. 16th, 1916. These were not exactly like those shown in the illustration, as the connecting bars of the bearings had only one traverse connection. These ties were allowed to season for two months before being laid on a straight track with an incline of 9.6 per 1,000 with an average of 20 trains passing over it in 24 hours; the maximum speed allowed is 60 miles per hour, and several trains with unusually heavy locomotives have gone over it.

The foundation of the track is composed of fine gravel mixed with earth; it may be considered of medium quality. The new ties have withstood and are still withstanding a continual heavy traffic without anything abnormal taking place either with regard to the level of the gauge of the track or the fastening of the rails to the ties, the last named remaining perfectly firm.

Unfortunately, from the first many of the ties showed cracks in the connecting bars and these developed in some bars until the latter appeared to be wearing away, though these defects in no way prevented the bars from doing their work, viz., to maintain the right gauge between the bearings.

In April, 1917, after the ties had been in use for five months, the Administration of the State Railways agreed that the trial had fully proved the fitness of the new ties, and that the insufficient resistance of the distance pieces (which was the only weak point which had been detected) could be easily remedied. A second lot of ties—2,000 in number—was then placed in continuation of the first hundred in a part of the track containing two curves of 1,600 ft. and 1,500 ft. radius, this second lot of ties being improved by the use of much closer connecting bars with more joints. The concrete of the connecting bars was also made independent of that of the bearings, by means of special concrete joints destined to give the necessary elasticity to the tie, and allowing for the slight twisting movements to which the ties are exposed on the passage of the trains as a result of the uneven pressure on the bearings. Slight alterations were also made in the arrangement of the reinforcement of the bearings.

The construction of the 2,000 ties was commenced on June 11th, 1917, at Naples, by the firm Ing. Comm. Carratu, which had supplied the first lot, and were ready by the end of January, 1918.

The preparation of the reinforcement was done almost entirely by women. The finished reinforcement was then placed in molds into which concrete was poured and pressed. The molds were removed gradually, the parts relating to the bearings being withdrawn on the second and those surrounding the connecting bars on the fourth day. On the tenth day the ties were seasoned under cover for two months, after which they were loaded on to railway trucks and sent to the place where they were to be used. Thus, in various stages, the manufacture and laying occupied from the middle of December, 1917, to the middle of September, 1918. A platelayer fixed the cones on the special parts of the bearings, fixing the outer cones first and then the center one between the others, striking it with a wooden mallet. The same man then leveled the heads of the cones with a hatchet, thus preparing the bearing surfaces of the plates. The tie is then put in position in a similar manner to that used with the ordinary wooden ties, the new tie being laid under the rails in the required position (Fig. 5), and the plugs are then screwed down as for other ties.

From the time of laying up to the present day, a little over two years, the ties have given satisfactory results, and no defects have been discovered.

Movable 3-Ton Concrete Bridge

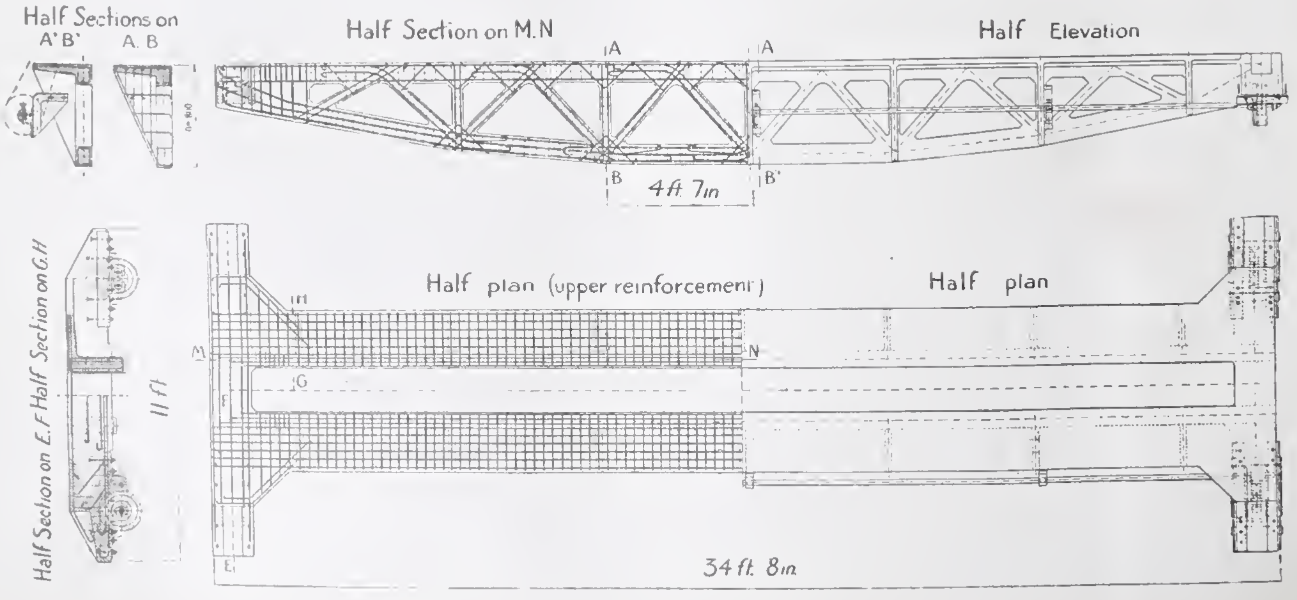
A particularly interesting use of reinforcement in concrete construction is shown in the following illustration, reproduced from Concrete and Constructional Engineering. This movable bridge has been constructed by the Etablissements Beccat in order to provide a structure of ample strength in which only a minimum amount of steel is used. It was designed so as to cause the least possible trouble with respect to new methods and appliances and so that its various parts could be produced by means of the same machinery and workmen previously employed by this firm and other bridge-builders.

The bridge has a total length of 34 ft. 8 in. and an over-all width of 11 ft. at each end, the central segment being 4 ft. 7 in. in length. The concrete consists of a mixture of 112 lb. of cement to each 154 cu. yd. of gravel and 70 cu. yd. of sand, with a crushing strength of 66 lb. per square inch and a coefficient of adhesion to the reinforcement of 66 lb. per square inch.

The weight of the bridge is consequently only half that of an all-metal structure of the same type. The weight might be still further reduced in future bridges by the use of slags and pebbles in the concrete, whereby an additional strength permits a further reduction of 18 per cent in the weight of the concrete.

The bridge has been designed so that in the members in compression the maximum load does not exceed 504 lb. per square inch in any part of the structure and the tensile strain on the steel does not exceed 16,800 lb. per square inch. The general arrangement of the reinforcement is shown in the illustrations.

Relative Time of Cutting Through Plain and Reinforced Concrete Pavements.—Information on this point is given as follows in The Surveyor of Aug. 29, 1919: In 1914 a certain gas company brought an action against a certain local authority who had laid down a reinforced concrete road foundation, claiming that by so doing it put them to extra expense getting to their mains. The judge who tried this case ordered a test to be made between plain and reinforced concrete. On Nov. 3, 1914, acting on the judge's instructions, John Mowlem & Co., Ltd., a large firm of London contractors, laid two sections, both of an area of 12 sq. ft. One was of plain concrete 12 in. thick, and the other reinforced 6 in. thick. The reinforcement was placed about 2 in. from the bottom and consisted of B.R.C. fabric, having wires of 10 and 5 gage. The concrete was a mixture of 6 to 1, and when both sections had been completed to nearly the thickness previously mentioned, a ¾-in. floating was made with cement mortar. This experiment was to determine the relative time to break holes of the same dimensions through each type of concrete. On May 11, 1915, five men started at 3:10 p. m. on each section to excavate holes, the dimensions being 3 ft. 2 in. by 2 ft. 2 in. Fifty minutes later the hole was completed through the reinforced concrete portion, while the other five men had not finished their work through the 12-in. section unreinforced. The concrete was an excellent quality of Thames ballast. The reinforcement in the reinforced section was cut with a cold chisel and did not give any appreciable trouble in breaking it up.



Movable 3-Ton Concrete Bridge Constructed by the Establissements Beccat.

Road and Street Monthly Issue

ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials

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Our Need of Mental "Coaches"

Last week we called attention to the fact that relatively few practicing engineers are systematic students of current engineering literature. We believe that this defect is mainly ascribable to the failure of teachers to inculcate the habit of searching for information. This week we purpose outlining how this habit may be acquired.

Nearly every man knows that it is desirable to exercise his body vigorously for at least an hour every day; but how many men do so? The fact that relatively few professional or business men take adequate exercise is sufficient evidence that knowledge of what should be done is not a sufficient guarantee that it will be done. We are all creatures of habit, and habit is stronger than reason, in most cases. Hence if men are not thoroughly habituated to exercise systematically, they will seldom do so, even though their reason tells them that they should. The same holds true of the habit of systematic searching for information. In the absence of such a habit, the average man will not read systematically for information. Haphazard reading is better than none, but it is far from satisfactory in its results.

Nearly every person will grant that he should be a systematic reader of the literature that relates to his specialty, but the majority will confess that they are not. Nor does it seem to lie within the power of many men to acquire a reading habit if they lack it. What can be done, what should be done to remedy this deplorable condition? In our opinion one of the best plans is to organize a club of men interested in the same problems. Then appoint one or more members of the club to "coach" the rest. We use the term "coach" in preference to "teach," for, although teaching should involve "coaching," it seldom does. Men need mental trainers fully as much as they need physical "coaches," if they are to rid themselves of bad habits and acquire good habits.

Local chapters of national engineering societies can perform no greater service than by organizing classes whose prime object is to develop a "thirst for information." In pursuing this end, study should be made of the methods of the Chautauqua Society. Also it will be well to read that part of the biography of Louis Agassiz that describes how he and his fellow students at the university "coached" one another.

This justly celebrated naturalist, a Swiss-American, furnishes one of the greatest object lessons in mental achievement through having acquired a burning thirst for knowledge. So insatiable was his appetite for facts that he could not confine his reading and his observation to his special field. A summer vacation in the Alps led him to study existing glaciers and the moraines of glaciers no longer existing. From this study he came to the conclusion that the northern part of the temperate zone in the northern hemisphere,

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

and the southern part in the southern hemisphere, had once been covered with a vast ice cap, and that huge glaciers had carved the continents within these areas. Here was a geological generalization of great significance, made by a man who was not a geologist. It startled the geologists of the world. Ridicule was heaped upon this "ice age theory" of man who "should confine his theories to fish," as Humboldt wrote him But investigation proved Agassiz to be right.

Now what gave this "piscologist" a deeper insight into geology than contemporary geologists had shown? Was it genius? Agassiz had but one kind of genius—the genius for systematic searching for facts and for drawing inferences from them. Both of these qualities had been developed to a high degree by his habits of studying. Indeed, this habit of studying constituted the only genius that he had. The German universities, then as now, were conducted as to develop this habit. To the training thus received from his German professors, Agassiz added a similar training from his fellow students. Read his biography if you want to see how a small group of students stimulated and trained one another to become thoroughly imbued with a persisting desire to acquire knowledge. If you lack such a desire, or if you have it in but lukewarm degree, the "Life of Louis Agassiz" may serve to point the way to become a bloodhound on the scent of useful facts.

Teach the Average Man to Invest in Public Works Bonds

During the first ten months of this year, the states and counties authorized the issue of $494,000,000 for road work. During 1920 there will be elections to vote on the issue of $773,000,000 of highway bonds. These, in round numbers, are the totals compiled by The Portland Cement Association. It is probable that fully a billion dollars worth of road bonds will be authorized in 1920 by the states and counties, exclusive of federal bond issues.

Although these are huge figures, it should be remembered that a dollar will buy only about half as much road work in 1920 as in 1914. Also it should be remembered that the production of motor vehicles is increasing much more rapidly than the mileage of improved highways. In short, road construction is relatively lagging behind the economic need. However, the same is true of every other class of public work. In spite of all propaganda, the public is not planning to do half the work that should be done. During 1918 all the cities of 30,000 or more inhabitants, with a total population of 34,300,000, spend only $278,400,000 for public improvements. This was regarded as a large sum, especially in war time; but it is only $8.10 per capita. What the expenditures for municipal improvements in 1919 will total is not easy to estimate. It will probably be less than $12 per capita, of city residents, an amount that is wholly inadequate.

It has been estimated that in normal times about 10 per cent of the annual gross income is invested in "permanent improvements"—plant, buildings, roads, etc. Prior to the war American gross income was 50 billion dollars annually. Hence about 5 billion dollars went into improvements each year. This percentage has always been economically inadequate, but, as a result of the war, it is becoming smaller rather than greater, the reason being that capitalists are being taxed very heavily. The average American wage or salary earner invests an almost infinitesimal part of his earnings. The great problem is how to convert the average American into an investor, but almost as great a problem is how to secure adequate propaganda for public works.

Profits from private works serve to attract capital into manufacturing, mining, agricultural and merchandising fields. Unfortunately the direct profit from investments in public works is merely a bond interest of 5 to 6 per cent, and the indirect profits—though often great—are not easily measured. Hence there is great need of organized propaganda to secure public improvements. Hitherto engineering societies have done very little to promote public works. There is a growing realization among engineers that it is not enough to be ready and able to design and build public works; engineers should induce the public to undertake public improvements that are economically justifiable.

In promoting road and street projects, for example, engineering societies and clubs should ally themselves with chambers of commerce and other organizations interested in public welfare. They should make it clear to the public why bond issues are economically preferable to taxes as a means of securing capital for permanent improvements. It should be pointed out that the owner of a road bond is like the owner of stock in a railway, the main difference being that the road bond holder receives a limited but certain profit and that his profits in excess of the bond interest come as indirect gains from lower transportation costs. He gets his share of these indirect gains because he is a member of the community that benefits from the existence of better highways.

Up to the present, nearly all highway bonds have been sold to large capitalists, but why should they not be bought by every income producer? Could they not be marketed as the "liberty bonds" and saving stamps were sold, by local committees organized to get every man to do his duty? Is it not a duty that every man owes to the community to help furnish the capital with which to improve its highways? Instead of relying upon the thrifty rich capitalists to buy the road bonds, should not every income earner rely upon himself, to the extent of his ability? If this were the general practice, nearly all men would be thrifty and very many would become rich as a result of their thrift.

The Mormon Church requires every member to pay a "tithing" to the church, and the "tithing" is a full 10 per cent of his income. Most of this "tithing" has been invested in property, until the church has become rich. Incidentally the Mormons, as a class, are very prosperous. In addition to the 10 per cent that each Mormon gives to the church, there is evidently a great deal saved by him. It would appear that the average Mormon saves fully 20 per cent of his annual income, half for the church and half for himself. Hence it can not be contended that the average wage or salary earning American can not save at least 10 per cent of his income. If this were done, it is evident that nearly 20 per cent of the gross annual income of all Americans would be saved, for the present 10 per cent saving comes almost entirely out of the profits and interest that capitalists receive.

What Does the Word "Freedom" Mean?

To one who has studied logic with care, the present controversy between the labor union leaders and the government officials forms an interesting example of diverse deductions from premises that are seemingly alike. Both sides in this controversy would agree to the following syllogism:

All just government is based on the consent of the majority of the governed.

The American government is just.

Hence, the American government is based on the consent of the majority of the governed.

The consent of the governed is secured periodically through representatives elected by a majority. This consent is partly embodied in the constitution of the United States and partly in laws. The present controversy is mainly centered on the meaning of the words "free" and "freedom" that occur in the constitution. Union officials put one interpretation on these words; government officials give them a different interpretation. So it is really futile to deduce anything from the constitutional premise that "all men are created free and equal," until there is an understanding as to the meaning of the term "free."

In deciding the meaning of any word in a contract, the courts are accustomed to take expert testimony, the object being to ascertain the meaning of the word commonly accepted in the given field under consideration. Also it is customary to study the context of the contract to ascertain the most rational meaning assignable to the word. But in the field of politics, each side is given to using its own interpretation of a word or term, often refusing to examine any other interpretation. Now precisely this sort of arbitrary definition of the word "freedom" is seen in the present coal strike controversy. The union leaders declare the strike injunction to be an abridgment of their "constitutional freedom"; the government asserts that it is not. The matter may eventually come before the Supreme Court for decision. If it does, we may be sure that the court will not turn to a dictionary to ascertain the constitutional significance of "freedom." Instead it will start with the self-evident fact that no freedom is limitless. Then it will inquire into the extent or degree of limitation permissible under the constitution.

Even the majority of the electorate is limited to its freedom, for there are many acts specifically prohibited. Freedom, in short, is always relative and never absolute in any society. When it has approached absolutism, it has ended in anarchy. Herbert Spencer's "Sociology" gives several instances of African natives that were so nearly absolute in their freedom they could not live together, even in small groups, without fighting with one another. So they seldom were to be found in groups larger than one family! That probably marks the limit of social freedom, but even there the head of the family imposed his will upon its members, and, to that extent, limited their freedom.

Now the fundamental question in the coal miners' strike is the degree to which the freedom to strike is properly limited or limitable by the rest of society in this country. All appeals to the principles of "freedom" in justification of the coal strike will be of no avail until there is an impartial decision as to the degree of freedom that a relatively small group of men may enjoy without injury to the rest of society Society has established courts as the impartial tribunals to decide just such matters as this; and in America the Supreme Court is the court of last resort. Let this great case go to the Supreme Court as speedily as possible, and, pending its decision, let the strikers follow the practice of citizens in all cases subject to court review—continue peacefully to follow their customary occupations.

Gompers' Mistake

Samuel Gompers recently stated that although union workers in America total only 4,500,000, they and their families represent 24,000,000 people. He said that each family numbers about 5 people, so he multiplied the 4,500,000 by 5, and then added 1,500,000 for good measure, to get the 24,000,000. In multiplying by 5, he tacitly assumed that each worker is the head of a family, but, as a matter of fact, there are only 2.6 people to each worker, which means that there are two workers to each family. In "Vocational Guidance," by Pieffer, the following percentages, based on the U. S. census, are given:

	Per cent.
Non-workers (too young or too feeble)	39
Home makers	23
Workers	38
Total	100
Workers:	Per cent.
Agriculture	30
Manufacture, mechanical and mining	23
Domestic and personal service	16
Trade and transportation	13
Professions	4
Idle	14
Total	100

Assuming that Gompers is correct in stating that there are 4,500,000 union workers, that is only 4 per cent of the population. Since there are 2.6 people per worker (include the worker), only 4 × 2.6 or 10.4 per cent of the total population are members of families that belong to unions. This is about half what Gompers erroneously claims the percentage to be.

Since barely one person in ten in America is a member of a family that is represented in any labor union, it follows that there is small likelihood that labor union threats will intimidate many legislators. Consequently it is a foregone conclusion that anti-strike laws of some sort will soon be passed by congress, and later, by most of the states. The American public has about reached the limit of its patience, and talk about the inalienable right of free men to quit work is not meeting with a very kindly reception these days. "Free men" all Americans are, but our freedom is and always has been limited. Actions that harm one's fellowmen are not long permitted, even under the guise of freedom. Try disturbing the peace by loud shouting at night, if you want to test the extent of your freedom to use the lungs that God gave you.

Union of Draftsmen Withdraws from American Federation of Labor.—The following news item released last week by the National News Service is of especial significance: Washington, Oct. 29.—Declaring that high officials of the American Federation of Labor are responsible for "tendencies to threaten the foundations of the government of the United States," a union of draftsmen employed in the Treasury Department has today withdrawn from the American Federation of Labor. The movement is part of a general campaign to secure withdrawal by all government employes unions.

"Economic Limits of Motor Trucks Weights"

To the Editor: In the article on the "Economic Limits of Motor Trucks" on page 375 of your issue of Oct. 1, 1919, an error, repeated three times, appears to be an error of text rather than type.

It may shock some designers to be told that the thickness of a homogeneous concrete or reinforced concrete slab to distribute a given column load to earth below at a pressure of 1,000 lb. per square foot need be no thicker, or thinner, than if the pressure below the slab was 10,000 lb. per square foot, when the plans of the footings are regular, similar and concentric, when the pressures are within the limits of yielding without flow of the subgrade, and the deflections are not so large as to be objectionable.

When a slab type of pavement distributes a concentrated or wheel load W over a circular area of subgrade whoso radius is R the pressure per unit of area will be $Pa = W/\pi R^2$; the critical section obtains at the point of maximum moment and must therefore be at the periphery of the circle or pass directly under the load.

The exact determination of the moments is complicated but the moment at the periphery or on a section through the center may be assumed at zero. Or any value intermediate between zero and the maximum and the value at the other section can then be readily computed.

It is a simple problem to solve between the possible limits and divide the total moment between the two sections in the manner commonly used in building construction, when the moment at the center of a fixed beam is assumed to be equal WL/12 and at the end of the span equal WL/10.

One is just as reliable as the other.

To illustrate, assume the moment at the edge of the circle equals zero.

The moment at a section through the center will be

$$M_b = Pa.\frac{\pi R^2}{2}.\frac{4R}{3\pi} = \frac{2}{3}W\frac{R}{\pi} = .2122\,WR.$$

The moment of resistance of the section will be $M_r = 1/6fbd^2 = f.2R.d^2/6 = .333fRd^2 = .2122WR. = M_b$.

Hence, $d^2 = .6366W/f$ and $d = .798\sqrt{W/f}$ in which f is the unit fiber stress in the slab.

For good plain concrete, f may be taken at 100 and the equation becomes, $d = .0798\sqrt{W}$.

Similar simple equations may be written for the case in which the moment at the section through the center is zero and the moment at the edge or periphery of a circle, square or any other regular polygon is maximum, also, for cases in which the pressure on the sub-grade is not uniform but varies according to some established law or assumption, with the result, in each case, reduced to the form $d =$ A constant $\times \sqrt{W}$.

The moments for all intermediate values between zero and maximum at both edge and center, and at all intermediate points between edge and center may be reduced to the simple form

$M =$ A constant $\times$ W and

$d =$ A constant $\times \sqrt{W}$.

both entirely independent of the value of Pa.

When analyzed by strictly statical methods the value Pa may always be eliminated in the final result, so it must be evident that the equations in the form $d = \sqrt{W/Pa}$, $d = \sqrt{W/4Pa}$ and $d = b\sqrt{W}$ in the latter of which b is a function of Pa, are all erroneous.

The graceful process by which the formula $d = \sqrt{W/Pa}$ is developed does not inspire confidence in the remainder of the discussion.

For a more complete analysis of this problem readers are referred to page 186, Vol. 41, of Engineering and Contracting, Feb. 11, 1914, and to an editorial article in the same issue entitled "Stresses in Concrete Roads and Required Thickness of Slabs."

Writers on concrete road design generally state that the thickness is purely a matter of guess work, or superior judgment, although not often stated in so brief and unmistakable terms.

The cross-sections are usually thicker at the center than at the edges, while purely rational design dictates that after reasonable allowance for greater wear along the central portion of a road or pavement, the edges should be much thicker than the central portion or heavy traffic should be barred from the edges of the slab.

J. W. PEARL.

Chicago, Ill.

[In accordance with our custom the above letter was submitted to Mr. Robert C. Barnett, author of the article on the Economic Limits of Motor Truck Weights. His reply follows.—Editor.]

To the Editor: I have looked over Mr. J. W. Pearl's comments on the formula for pavement thickness given in my recent article. It seems that the criticism is based on a confusion of concepts—on a failure to differentiate clearly between the "bearing capacity" of the subgrade which is a function of the physical properties of the soil, and the "average unit pressure" on a footing which is a function of the load and of the area over which the load can be distributed by the slab. These are two quite different things.

Although Mr. Pearl apparently eliminates P_a from his formula for bending moment, he still retains the factors of W and R upon which the unit pressure (not bearing capacity of soil) depends.

It is true that the design of pavements now rests largely on empiricism; but there are two fundamental facts, gleaned from the experience and observation of road builders and designers, which stand out clearly. These are:

First. The heavier the load for a given subgrade condition, the thicker must be the pavement.

Second. The less the bearing capacity of the subgrade, the thicker the pavement must be for a given load.

Mr. Pearl admits that the thickness of the slab varies as the square root of the load. We are agreed upon that point. Does he deny that a soft subgrade would require a thicker slab for a given load than would a good hard subgrade? If not, there is no real issue between us.

The constant b in my equation is an empirical one and, of course, has different values for different subgrades and for different types of pavements—such values as experience dictates.

It was foreign to the purpose of my article to discuss pavement design, as that is but a detail of the larger problem. Each step taken in the solution of that larger problem will have to stand or fall on its own merits. I invite constructive criticism and would be glad to have Mr. Pearl present a better formula than the one I have adopted as conforming with our present state of knowledge. The wholesale condemnation of the article, because of disapproval of one detail, savors of the legal type of mind rather than of an engineering one.

ROBERT C. BARNETT.

Kansas City, Mo.

A. A. E. to Have Membership Drive.—The American Association of Engineers will conduct a membership drive during the first two weeks of December. The method to be employed is similar to that used in obtaining subscriptions to the Liberty Loans.

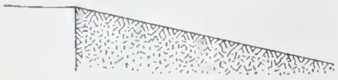
The 90 clubs and chapters will divide their members into membership teams, each with certain territory to cover, and under the supervision of a team captain. The drive will be handled for each chapter by a drive commander who will keep in direct touch with the national headquarters of the association by telegraph. He will make telegraph reports of the number of applications obtained each day. A force will be maintained at the national headquarters to tabulate the returns and to advise the chapters of their standings.

Pennsylvania Automobile License Fees Will Total $5,100,000.—Automobile license receipts by the Pennsylvania State Highway Department have passed the $5,000,000 mark. The total receipts of the automobile division from all sources during the year ending Dec. 31, 1918, were $4,048,185.50. The total number of registrations for that period was 678,786 of which 363,001 were for pneumatic tired vehicles. The number of pneumatic tired vehicles registered in 1919 up to Oct. 18 was over 435,000. These registrations, the state highway department expects, will continue within a few days of the close of the year and it is estimated that by Dec. 31, the total receipts of the automobile division from all sources will be in the neighborhood of $5,100,000 to $5,125,000.

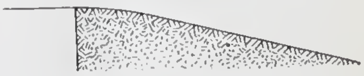
Bridge Approaches

It frequently is advisable to raise the floor of a bridge above the elevation for the roadway leading to the bridge. The principal reason for this difference in elevation is the necessity of securing ample clearance between the maximum high-water level and the bridge structure in order to pass floating debris. These differences of elevation lead to the necessity of connecting the two elevations—the bridge floor and the road surface—by a suitable ramp, concerning which a number of points deserve more attention than generally is given to them. An interesting discussion of this subject appears in the August-September Public Roads, from which the matter following is abstracted.

Economy in road design dictates that the elevation of the roadway should be selected without any reference whatever to the elevation of the bridge floor. The elevation of the roadway at any point is dependent on such factors as foundation conditions, drainage gradient, etc., and when these conditions are satisfied, whatever addition is made in the height of an embankment must be recognized as involving additional risk to high speed traffic, additional construction cost and additional maintenance cost and, therefore, demanding full justification.



Wrong Type of Approach.



Right Type of Approach.

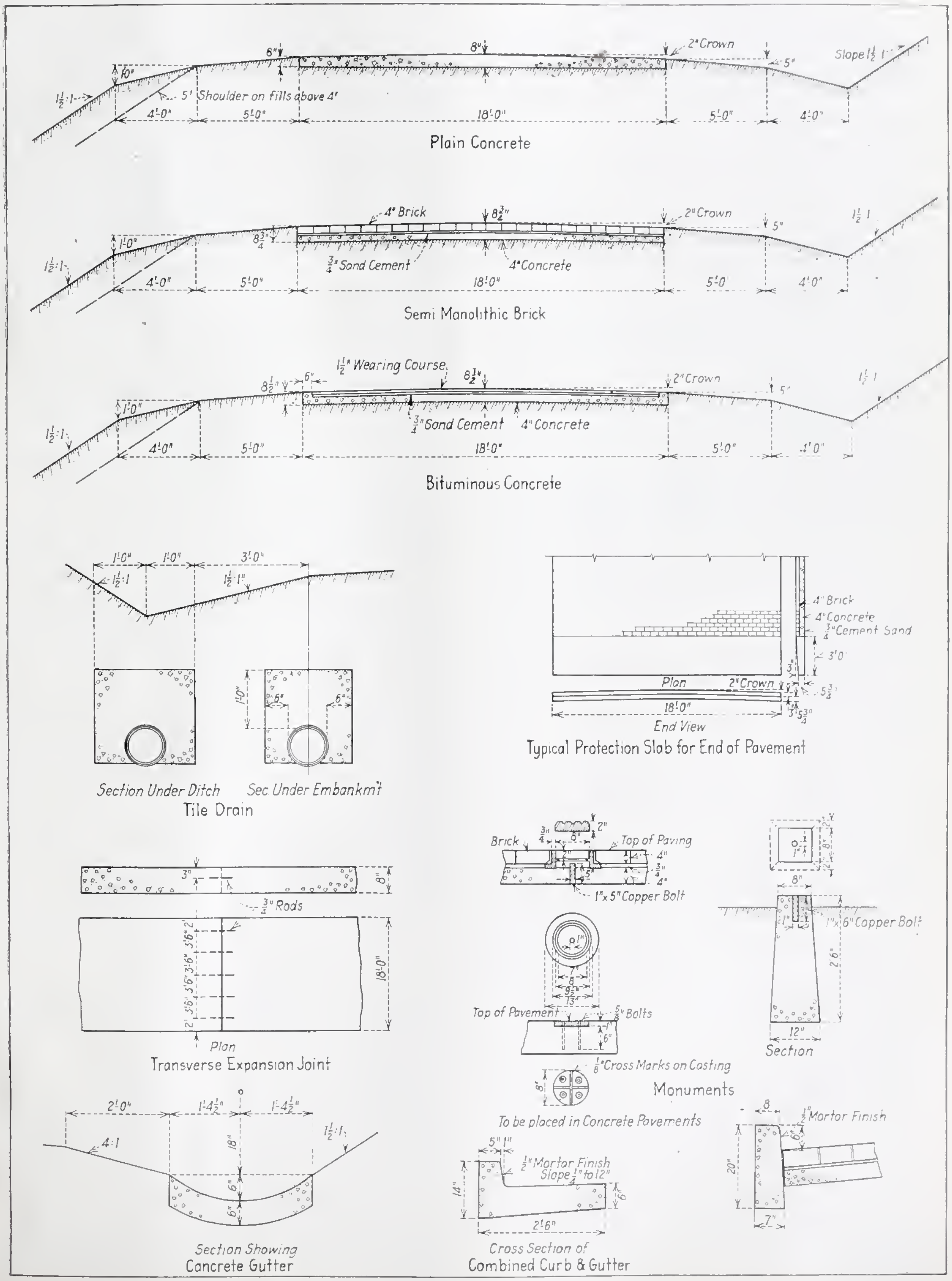
On the other hand, the logical result of all this is short ramps which, though somewhat to be condemned on the ground that they mar the beauty of the roadway are, nevertheless, in the interest of economy. This is particularly true where a bridge crosses a stream laying in a low, flat valley, the stream carrying enough drift to require rather a high clearance. In such cases the difference in elevation between the economical level of the road surface and the proper elevation of the floor of the bridge may be considerable and it is seldom economical or advisable to raise the road grade to the elevation of the floor of the bridge, as such a procedure would involve a considerable amount of expensive embankment. The obvious solution, then, is the construction of a comparatively short bridge approach and the real problem lies in the choice of a gradient for such approaches.

The present tendency is to build bridge approaches on long easy grades, but this involves a heavy expense and tends to nullify the gain accruing from the independent selection of the proper elevation for the bridge floor and for the roadway. A better practice is to base the gradient of the approach on the ruling grade in force on other parts of the road. In other words, if there is a 10-ft. difference in elevation between the normal position of the road surface and the proper elevation of the floor of the bridge and if 5 per cent grades are common throughout the length of the road, there is no particular reason for constructing the ramp connecting these two elevations on less than a 5 per cent grade, particularly as the shorter ramp will usually be less expensive and should be more easily maintained than a longer structure built on a light grade.

Ramps used for bridge approaches should be built full width. It frequently happens that where the shoulder width of the road proper is, say 24 ft., and the clear width of the bridge floor is 16 or 18 ft., the ramp is allowed to pinch down in width as the bridge is approached until there is a distinct constriction at and near the bridge. It is much better practice to provide abutments which will enable the use of full width ramps, or if this is, for any reason, inadvisable to fence approaches which are of any considerable height.

Finally, breaks in grade between bridge approaches and the elevations which they connect should be eased by the use of vertical curves under the same rules which apply to breaks in grade at other points along the highway. The use of easement curves will somewhat increase the length of bridge approaches because of the necessity of building the whole of the easement in the approach. However, this is not a matter of great importance and the added cost is more than justified by the fact that approaches which have been properly eased are a distinct assistance in driving on to and off of a bridge structure. Moreover, they make the maintenance of a road at the bridge very much simpler.

Standard Pavement Sections and Details of Indiana State Highway Commission



New Specifications of Indiana Highway Commission for Concrete Roads

The recently issued standard specifications of the Indiana State Highway Commission, of which H. K. Bishop is Chief Engineer, for concrete, vitrified block and bituminous concrete pavements embody the latest practice. The standard sections for these types are shown on another page of this issue. The requirements for concrete road construction in particular, contain several new features, some of which are outlined in the following abstract from the specifictaions for 1-course plain concrete pavement.

Coarse Aggregate.—This coarse aggregate shall consist of crushed stone or screened washed gravel, uniformly graded from the maximum size to pieces ¼ in. in diameter. The maximum size shall be such that all will pass through a laboratory screen having circular openings not less than 1½ nor more than 2 in. in diameter. Not more than 5 per cent, by weight, shall pass a laboratory screen having circular openings ¼ in. in diameter.

Crushed stone shall consist of clean, tough, durable crushed rock having a French coefficient of wear of not less than eight and a crushing strength of not less than 16,000 lb. per square inch; this material shall be free from dust and flat and elongated pieces.

The gravel shall be screened and washed free of clay and coatings of any character. Any material containing shale, lumps of clay, disintegrated or rotten boulders, soft, flat or elongated particles shall be rejected. Unscreened or pit-run gravel shall not be used.

Joints.—At the close of each day's work and also at other times when the process of depositing concrete is stopped for an appreciable time, a butt construction joint shall be made at a right angle with the center line of the pavement. For this joint there shall be used a clean plank having a thickness of not less than 2 in.—a width not less than the thickness of the pavement and a length not less than the width of the pavement. The plank shall be cut through to crown of the finished pavement and shall be provided with openings to facilitate the placing of joint reinforcing rods. It shall be accurately set and held to place vertically and to a true line. Longitudinal reinforcing bars shall be placed 3 ft. 6 in. center to center and 3 in. below the finished surface of the pavement. These bars shall be of steel, ¾ in. in diameter or an equivalent sectional area and shall have a length of 4 ft., extending 2 ft. away from the joint on either side. These bars shall be incased in paper in a manner which will prevent a bond between the steel and concrete. Upon the resumption of work the plank heretofore specified shall be removed and concrete deposited against and in contact with the exposed end of the finished concrete. The contractor shall exercise extreme care at these joints and see that the pavement is absolutely level on each side of the joint.

Forms.—Outside forms for this work shall be of wood or metal, of the depth of the concrete, straight, free from warp and of sufficient strength when staked to resist the pressure of the concrete without springing. If of wood, they shall be 4 in. wide on top and a depth equal to that of the pavement and surfaced timber, or if of metal, they shall be of approved section and shall have a flat surface on top of not less than 1¾ in. The forms shall be joined neatly and tightly and staked securely to line and grade at least 200 ft. in advance of the point of placing concrete, and shall be cleaned thoroughly and greased or soaped before any concrete is placed against them.

Devices for Measuring Materials.—The accurate measurements of each of the materials composing and the production of a uniform mixture of the concrete are essential. The contractor shall furnish and use approved timing devices, a water measuring and discharging device, also boxes or pans of such dimensions as will give, when filled and struck, the extra volumes of aggregate required by the engineer.

Composition of Concrete.—The concrete shall be composed of 1 part portland cement, 1½ parts fine aggregate and not more than 3 parts coarse aggregate, totaling not more than 4½ parts of aggregates. The aggregates shall be measured separately and accurately by volume in such proportions as the engineer shall direct, so as to give the greatest density and strength.

A cubic yard of concrete in place between neat lines shall contain not less than 1.91 bbl. of cement.

The engineer shall compare the calculated amount of cement required according to these specifications and accompanying plans with the amounts actually used during each day's work, as determined by actual count of the numbers of sacks of cement used each day. If the amount of cement used on any day is less by 2 per cent than the amount hereinbefore required, the contractor agrees to remove all such sections and to rebuild the same according to these specifications at his expense.

Consistency of Concrete.—The consistency of the concrete shall be such that when a cylinder 6 in. in diameter and 12 in. in length is filled with concrete and tamped until all voids are filled and a slight film of mortar appears on the surface and the cylinder then removed, the vertical settlement or "slump" of the concrete shall not exceed 2 in. when a mechanical finishing machine is used, nor more than 4 in. when the finishing is done by other methods permitted in these specifications.

Mixing Conditions.—No concrete shall be mixed while the air temperature is at or lower than 35° F., and no material containing frost shall be used. Bags of cement or fine aggregate containing lumps or crusts of hardened material shall not be used. The concrete shall be mixed only in such quantity as is required for immediate use and any which has developed initial set or has been mixed longer than 30 minutes shall not be used.

Mixing Concrete.—Concrete shall be mixed thoroughly in a batch mixer of the broom and bucket type for a period of not less than 1 minute after all the materials are in the drum, and during this period the drum shall make not less than 14 nor more that 20 revolutions per minute. The entire contents shall be removed from the drum before materials are placed therein for the succeeding batch.

Hand mixing shall not be allowed except to finish out a section of concrete in case mixer should break down.

Placing Concrete.—The placing of concrete shall generally proceed up grade. Concrete shall be placed only on a moist subgrade. If the subgrade is dry it shall be sprinkled with as much water as will be absorbed readily. Where the pavement is to be laid adjacent to railway tracks or around structures, no concrete shall be placed until the tracks and structures have been set to the required grade and alignment in advance, and all structures which project through the pavement shall be cleaned thoroughly to permit adhesion of the concrete.

The concrete shall be deposited on the subgrade rapidly in successive batches, by means of a discharging device, such as the boom and bucket type, which does not cause separation of the mortar and coarse aggregate and shall be distributed to the required depth and for the entire width of the pavement by shoveling or other approved methods. Rakes shall not be used for handling concrete. This operation shall be continuous between transverse joints without the use of intermediate forms or bulkheads. In case of an unavoidable interruption, a transverse joint shall be placed at the point of stopping work, provided that the section on which the work has been suspended shall not be less than 10 ft. in length. Sections less than 10 ft. in length shall be removed.

Finishing Concrete.—The surface of the concrete shall be struck by means of a steel templet weighing not less than 400 lb., for a length of 19 ft. The templet shall be of a built-up section consisting of an 8 in. steel channel reinforced with a steel "I" beam, "T" rail or "angle" in such a manner as will give it sufficient strength to retain its shape under all working conditions. The templet shall be crowned to the desired cross-section and shall be moved with a longitudinal and crosswise motion moving always in the direction in which the work is progressing.

Immediately after the concrete has been struck off it shall be rolled with an approved metal hand roller having a smooth even surface, approximately 6 ft. in length, 12 in. in diameter and weighing not more than 100 lb. This roller shall have a handle at least 2 ft. longer than the width of the pavement, and all the rolling shall be done from one side of the pavement. The roller shall pass from one edge of the pavement to the other in one operation, and the rolling shall continue until free water ceases to come to the surface.

After the rolling has been completed, the concrete shall be finished by using a belt made of canvas or rubber belting not less than 12 in. in width nor less than 2 ft. longer than the width of the pavement. This belt shall be worked with a longitudinal and crosswise motion as described for steel templet. Care shall be observed in the use of the belt not to permit the edges to dig into the surface of the concrete or to work the crown out of the pavement. The use of an approved type of finishing machine will be permitted.

The edges of the concrete shall be rounded with an approved edging tool having a radius of approximately ¾ in.

Protection of Concrete.—As soon as finished, the concrete shall be protected by a canvas covering, suspended not less than 12 in. above the surface, and if directed, the surface of the pavement shall be sprinkled with water. When the concrete has hardened sufficiently, the canvas covering shall be removed, the sides banked with earth and then the entire surface of the pavement shall be covered with water and kept covered for a period of 15 days. The water shall be over the entire surface of the pavement and shall be at least 2 in. in depth at the shallowest point. The contractor shall provide sufficient pumping capacity to at all times keep the pavement flooded with water while it is curving. On grades over 2 per cent where it is impracticable to flood the finished work the surface of the concrete shall be wetted thoroughly and covered with earth or other approved material to depth of not less than 1¼ in. This material shall be kept moist at all times by sprinkling with water and shall remain on the concrete for a period of not less than 18 days under the most favorable conditions, or for a longer period if directed by the engineer, during which time traffic shall be excluded from the concrete by the erection and maintenance of suitable barricades, and satisfactory precautions shall be taken to exclude foot traffic for a period of not less than 3 days.

When required or approved, other methods of curing and protecting the concrete may be used.

After the foregoing period has elapsed, the covering on the concrete shall be removed, the surface of the pavement swept clean and the concrete allowed to cure for a period of 3 days, after which the roadway may be opened to traffic. In no instance shall traffic be allowed on the pavement before 21 days after the concrete was laid, and in cold weather the road shall be kept closed for a longer period, the time to be determined by the engineer.

Uneven Surface to be Remedied.—Should there appear at a joint, or other point on the concrete pavement surface, any unevenness amounting to ¼ in. or over, above or below the general contour of the surface of the concrete, then the contractor shall take such means as will be effective to remove such unevenness and produce a true surface, but no depressions shall be remedied by filling with concrete or other material unless the concrete slab has been cut so as to insure a thickness of at least 4 in. for the new material and with sides cut vertical. If any such depression requires a patch of this character of over 2 sq. ft. in extent, then the entire slab of concrete shall be cut through to the foundation for the entire width of the road and new concrete placed as to produce a true surface.

Concrete Shall Not Be Placed During Freezing Weather.—Concrete shall not be placed when the temperature is at or below 35° F. All concrete placed when the temperature shall reach 35° F. or below within 18 hours thereafter shall be at the contractor's risk and shall be replaced at his own expense upon written notice from the engineer.

Concrete shall not be placed upon a frozen subgrade.

Cost of Heating and Spreading Road Oil at Los Angeles.—In the latter part of July, 1918, the city of Los Angeles, Cal., placed in operation a municipal plant for heating the oil used for street purposes. The first cost of the heating plant including the retort was $11,871. Three oil spraying trucks were purchased at a cost of $17,014, and a garage for them was erected at a cost of $876. The average cost of the oil heated at the plant and spread by the trucks was $2.52 per barrel for the year ending June 30, 1919. A total of 32,008 bbl. was spread in this time. The following figures from the last annual report by A. C. Hansen, City Engineer, show the average unit costs:

	Per bbl.
Oil and heating	$2.25
Spreading	.26
Superintendence and overhead administration	.01
Total	$2.52

The oil was purchased, delivered on siding alongside the plant at a price of $2.09 per barrel, prior to Nov. 8, 1918; after that date it cost $2.29 per barrel.

Central Loading Plant Facilitates Street Paving Work

A particularly well planned central loading plant was employed by J. S. McLaughlin & Sons, Red Oak, Ia., in constructing 95,865 sq. yd. of concrete street paving at Spencer, Ia. The plant, a description of which appears in the September Concrete Highway Magazine, was designed with a view to using the smallest possible number of laborers and to get the most out of mechanical equipment.

While the preparation of the subgrade was going on, three large bins and a shop building were erected on vacant property alongside a railway siding. One bin was for stone, one for bulk cement and the third for sand, while the shop is for truck repair and storage of tools and miscellaneous materials.

A crane equipped with a clamshell bucket lifts the crushed stone from gondola cars on the siding and deposits it over a wood box tunnel a little above ground level. The tunnel is equipped with gates or trap doors operated from below by short-handled levers. The stone falls through these gates upon a conveyor belt that carries the material to a bucket elevator, which in turn empties it into the top of the loading bin. From the bin the stone runs by gravity into a measuring box which is mechanically emptied into trucks.

Bulk cement is delivered to the cement bin in freight cars, which are unloaded by a power-driven scoop. The cement is carried to the top of the bin by bucket conveyors and is measured in a box before emptied into the trucks.

Sand is handled in much the same manner as the stone. As the source of supply is local, the contractors use their own 5-ton motor trucks to haul it from the washing plant to the bin. The loaded trucks run up an incline onto the platform, dump their loads, and the sand is carried by belt conveyor and bucket to the bin, from which it is measured into the trucks.

Electric motors supply the power which operates the conveyors and elevators for each bin. This has proved eminently satisfactory and economical.

Materials are hauled from the loading plant to the mixer by a fleet of ten standard Ford trucks with specially designed bodies. These first receive the correct amount of sand at the sand bin. They then pass under the cement bin, receive there the right amount of cement and proceed to the stone bin, where the correct volume of that material is loaded on top of the cement. The proportions being completed, the loaded trucks proceed to the mixer over a haul averaging about a mile. Traveling on the subgrade, they back up to the mixer, dump the material into the skip and return to the plant.

The mixer is equipped with a drum having a rated batch capacity of 28 cu. ft. Only 24 cu. ft. are carried in the trucks for each batch, and the concrete resulting is well mixed during the one-minute period specified. The proportions 1:2:3 are rigidly adhered to, the cement content being 1.7 bbls. per cu. yd. On July 8th a check was made of the amount of cement used in the first 13,000 sq. yds. of paving and it was found to exceed requirements by approximately 2 per cent.

Records show that an average run during a 10-hour day produces 1,200 sq. yd. of finished pavement. The high run has been 1,580 sq. yd. This accomplishment is all the more remarkable because integral curb is being built at each side of the pavement, and the pavement is being reinforced with steel rods. The section is 6 in. thick, one-course construction. Reinforcing is 2 in. from the finished surface. The roller and belt method of finishing is employed and precautions are taken to prevent too rapid drying out of the finished pavement, by a covering of earth kept wet.

There are 47 men employed in the different operations from the arrival of the material on the cars to the finished pavement, the distribution being as follows:

At Loading Plant—
- 1 foreman.
- 1 mechanic.
- 2 men at stone bin.
- 3 men at cement bin.
- 2 operators for crane clamshell.
- 10 drivers for Ford trucks.

At Concrete Mixer—
- 1 foreman.
- 2 mixer operators.
- 2 men at strip of mixer.
- 2 men at chute.
- 3 concrete spreaders or graders.
- 2 men placing steel reinforcing.
- 5 men finishing.
- 2 men on roller and belt.
- 5 men covering finished pavement, watering it and removing forms.
- 2 men on miscellaneous duties.

Storage Tanks for Road Oil Cut Out Demurrage

By CHARLES E. MURPHY,
Asphalt Sales Department, The Texas Co.

Demurrage charges are aggravating not only to those who pay them but also to the companies to whom they are paid. They are an obnoxious expense; a sort of a tithe or levy paid for something which one doesn't get. Yet, they are necessary; in fact, without them the transportation facilities of the country would be in a continual state of chaos; lengthy delays in deliveries would be the inevitable outcome, and the sums invested by railway and commercial companies in cars, rails, and land would be tripled at least.

The reason for these things is obvious, because if consignees or persons to whom cars are shipped were allowed to let the cars remain in the freight yard or on the siding for an indefinite period, then more cars would be needed, more rails would be required, and additional space for freight yards and sidings would be a necessity. Consider what an enormous amount of additional capital would have to be invested!

Discarded Gasoline Tank of 15,000 Gal. Capacity Utilized as Storage Tank for Asphaltic Road Oil.

To take a practical example. Suppose a certain freight yard accommodates 1,000 cars, each car occupying approximately 40 ft. of track. In all they would occupy track space to the extent of 40,000 ft., and if all the cars were left there two days, during that period no more cars could be admitted to the yards. However, if 500 cars were unloaded and moved from the yard in the first day, then 500 new cars could be admitted the second day. If this could be continued at all times then every two days the freight yard would be occupied by a completely different group of cars. But, if delay existed and it was impossible to allow a number of cars—say 200—into the yard for three days, then space at other places would have to be provided for the 200 cars. In other words, 8,000 ft. of track space would be necessary.

Not only do the railroads suffer from such delays, but also companies which own cars. Their material is demurred in delivery, their cars are held up for several days, and all this means additional cars at tremendous expense. One could continue giving the reasons for demurrage and its consequent havoc, but chapters would be consumed in doing so. The real point is to offer some helpful way to avoid it, even if it gives only slight assistance or is provocative only of some other remedy.

Storage tanks offer about the most efficacious method for obviating demurrage charges. Municipalities which have made use of this system will attest to this, for since their installation these communities have paid little or no demurrage. Of course, there are expensive types of storage tanks and types which cost comparatively little. No matter which is installed, however, each offers a place to deposit the material until it is needed, it allows for the early return of the cars, and gives the contractor or municipality a feeling of confidence that the commodity is always on hand for use.

In this article we shall simply consider a novel type of storage tank which has cut out entirely the necessity for the town of Southampton, Long Island, paying demurrage charges in certain districts of the community. One may follow better the description of this storage tank by scrutinizing the accompanying photograph of it.

The tank is a discarded gasoline tank with a capacity of 15,000 gal. It is placed in a firm but inexpensive concrete base so that all dampness and immediate contact with water on and under the ground will be avoided, and is situated near enough to the railroad siding to allow for direct pumping of the asphaltic road oil to it from the tank car. A rectangular wooden platform is built a few feet above the tank, supported by four props and crosswise braces. The hand pump which extends through the dome cover rests on the platform, and is placed at such a height that the man's back who uses the pump is not broken by operating it. From near the top of the hand pump an ordinary tin pipe extends out to the distributor for filling purposes.

Rain and moisture are prevented from entering the tank by placing the dome cover tightly on the tank during storms. The proximity of the storage tank to the railroad siding makes it possible to unload an 8,000 gal. tank car of asphaltic road oil in about an hour. Consider this factor in facilitating the early return of the car to the company owning it, the precluding of demurrage charges, and the fact that the road oil is on hand for use at any time.

It must be apparent that other types of tanks could be utilized by contractors and municipalities for this purpose. Though inexpensive, they furnish a great accommodation, and will serve the purpose until more permanent tanks can be installed.

Cost of Street Repairs at Los Angeles

Repair of all streets at Los Angeles, Cal., not permanently paved with asphalt, brick, concrete, or other similar materials is carried out by the Street Maintenance Department.

Minor repairs to improved streets are made by a mixture of hot road oil and gravel. This material is obtained from city plants. The oiled gravel mixture is made by obtaining properly graded sand and crushed stone from the city crusher, adjoining the mixing plant, running this and the proper proportion of hot road oil through a concrete mixer, after which the material is loaded in trucks and wagons for distribution throughout the city. During the year ending June 30, last, 9,569 cu. yd. of the mixture was used at a cost of $1.87 per cubic yard.

Where the condition of the surface of improved streets requires it, reconstruction is accomplished by rooting, rolling and oiling. After the gutters are thoroughly cleaned the entire surface is rooted with a rooter, having from three to five points, according to the strength of the roller. The lumpy surface is then pulverized with a discing machine also pulled by the roller. A heavy application of water is made and after grading, rolling, regrading and rerolling the surface is ready for oiling. A slight delay is sometimes advisable, as street traffic will considerably assist in making the surface more compact. Road oil, containing at least 81 per cent asphaltum, is applied, and covered with sand or rock screenings. Work of the above nature is done only after an inspection by the superintendent shows that it is necessary and reconstruction equipment is apportioned so that each part of the city gets a just amount of this work.

The cost of this work in 1918-19 according to the report of A. C. Hansen, City Engineer, for the year ending June 30, last, was as follows:

	Miles.	Per mile.
Rooting, discing, grading and rolling	156	$317.60
Oiling	150	518.90
Crushed rock and sand for	150	501.65
Wetting surface for grading	156	60.00

A. A. E. and Licensing of Engineers.—The board of directors of the American Association of Engineers, at its quarterly meeting on Oct. 11, adopted a resolution announcing a militant attitude of the association toward licensing and registration of engineers. Every effort will be made to have a license bill enacted in every state in which there is none at present. Chapters were advised to appoint license committees, each of which is to co-operate with the National License Committee in drafting the national bill for adoption in all states. Action will be taken also to insure enforcement of existing license laws. The resolution states that "it shall be the duty of chapter committees to see that the law is enforced, both in letter and in spirit, and that such amendments are made to the law from time to time as experience renders advisable in order that the profession may be kept in a high plane."

Effect of Size of Residence Lot on Cost of Street Improvements and Utilities*

By MORRIS KNOWLES.
Consulting Engineer, Pittsburgh, Pa., and Windsor, Ont.

It should be understood that there are other factors affecting the size at which lots should be designed, in addition to street improvements and utilities. It will be advantageous therefore to present a brief statement of these other various factors, in order that phases which are considered in this paper may be co-ordinated with them. Such factors are:

1. Cost of land.
2. Size and arrangement of rooms in house.
3. Certain improvements that lie within the boundaries of the lot, such as grading (which is affected by topography), planting, fences, hedges and house walks.
4. Desirability of a front yard to properly set off house and to establish privacy from passers on street.
5. Desirability of a side yard to ensure sunshine, proper ventilation, adequate fire protection and suitable approach to rear.
6. Desirability of a rear yard to provide space for clothes line, house garden, garage perhaps, and playground for the children.

Elements Not Related to Size of lot.—There are elements, even of street improvements and utilities, that in no way are related to size of lot. For example:

(a) Those divisions of utilities that lie outside townsite boundaries, as water supply plant, both pumping station and filtration units; sewage treatment and disposal plants; power plant to generate electricity; steam plant in event houses are to be heated from a central heating station; and in some cases a gas plant, though it may be doubtful whether such a plant would be erected.

(b) Various trunk supply lines which lead from the respective supply plants to townsite. These include water supply trunk line; gas and steam trunk lines; electrical transmission line; and sewer outfall line.

(c) There are certain portions of street improvements and utilities lying even within boundaries of townsite which are not directly and immediately affected by size of lot. For example, those street improvements and utilities that lie directly in front of house and that parallel the depth of house. These portions of utilities and street improvements are more affected by size and arrangement of house than by dimensions of lot Likewise, there are certain elements of house connections which are not affected by size of lot; for example, connections to mains, curb-boxes, stop cocks, meters and the portions of house services that lie within the street.

The foregoing elements bear an important relation to the cost of utilities, in so far as they affect cost per capita or cost per house, but they are not in any way related to size of lot.

A well defined statement regarding those portions of utilities and street improvements which directly relate to size of lots can now be made.

(a) They include street improvements and utilities located directly in front of the space lying between houses.

(b) Street improvements and utilities located on minor streets that lie parallel to space occupied by front yards and by rear yards.

(c) Lengths of house service connections which are located in front yards and in rear yards.

Relative Costs for Assumed Townsite.—In order to estimate relative costs, it will be necessary to assume a town layout. Following are the factors:

An industrial town with 1,000 houses. Houses are 22 ft. wide and 30 ft. deep. Lots are 42 ft. front by 80 ft. deep. Houses are located on center line of lots and are placed 15 ft. back from front property line. Main streets are 50 ft. wide; minor streets 40 ft. wide. Main streets have 24-ft. paved roadway, 5½-ft. planting strips, combined concrete gutters and curbs, and 5-ft. sidewalks. Alleys are omitted. There are 24 houses in each block, making length of block 504 ft. and width 160 ft. There are approximately 42 such blocks in the townsite. Filtration plant and pumping station is assumed, two miles from townsite; sewage disposal plant, one mile away; and electric transmission line and gas tank line each three miles long. Assumed that it will not be necessary to build electric plant or gas plant.

TABLE I—ESTIMATED COST OF HOUSE AND IMPROVEMENTS.

Item.	Cost per house.	Per cent of total cost.	Including overhead.
House	$3,000.00	54.85	64.0
Land	336.00	6.14	7.2
Lot improvements	232.64	4.25	1.9
Street improvements	463.29	8.48	9.9
Water system	190.15	3.48	4.1
Electrical system	26.33	0.48	.6
Gas system	101.18	1.85	2.1
Sewers—Storm and sanitary	202.48	3.70	4.3
House connections	138.50	2.53	2.9
	$4,690.57		
Engineering and supervision at 10%	469.06	8.58	
	$5,159.63		
Interest at 6%	309.58	5.66	
	$5,469.21	100.00	100.0

It will be noted from Table I house is 64 per cent of total cost, including distribution of overhead; land with lot improvements, 12.1 per cent; street improvements, 9.9 per cent; water, electrical, gas and sewer improvements, with house connections, 14 per cent. Engineering, supervision and interest charges, which are distributed in these statements, are 14.24 per cent of the whole.

Figures shown in Table II are cost per lineal front foot of side yard and per lineal foot depth of front and rear yards. Costs per lineal foot lot frontage and depth would be greater, as cost of house meters, shut-off valves, etc., would be included in this cost.

TABLE II—COST OF UTILITIES AND STREET IMPROVEMENTS PARALLEL TO YARD SPACE.

	Cost for length parallel to 20-ft. side yard.	Cost per lin. front ft. of side yard.	Cost for length parallel to 50-ft. front and rear yard.	Cost per lin. ft. depth of front and rear yard.
Street improvements	$178.60	$ 8.93	$ 55.00	$1.10
Water system	36.40	1.82	13.00	.26
Electrical system	4.20	.21	.00	.00
Gas system	17.40	.87	6.50	.13
Sewers—Storm and sanitary	54.00	2.70	17.00	.34
House connections	.00	.00	32.50	.65
	$290.60	$14.53	$124.00	$2.48

The results in Table II show that if space between houses on main streets is increased 1 ft., cost of utilities and street improvements per house is increased $14.53. If front or rear yard is increased 1 ft. in depth, cost of street improvements and utilities per house is increased $2.48. These computations bring out the interest fact that in so far as street improvements and utilities are concerned, 5.86 ft. can be added to depth of front or rear yard for same cost of adding 1 ft. to width of side yard.

Assuming for sake of comparison a lot 42 ft. front by 80 ft. deep, the combined cost of land and lot improvements is equal to $568.64, or $13.54 per front foot. (See Table I). If, for this lot, costs of main and minor street improvements and utilities are combined and quoted as cost per lineal front foot of side yard parallel to yard space, they equal $20.73 per lineal foot.

If the cost of land and lot improvements be combined with cost of utilities and street improvements on main street parallel to side yard, the cost per lineal front foot of side yard is $28.07. Assuming rents based on 10 per cent return, rent for each front foot of side yard is 23 ct. per month, of which 12 ct. is for street improvements and utilities, and 11 ct. is for land and lot improvements. This is the cost of air and sunshine, or $4.60 per family per month.

While no sweeping conclusions can be made, because we have discussed only one assumed townsite, it is interesting to note that cost per lot for "street improvements and utilities" is $1,121.93, compared with $568.64 for "land and lot improvements," the latter being 50 per cent of former. If however, we compare cost per front foot of those elements of street improvements and utilities directly related to size of lot, with cost per front foot of lot improvements and land, they are respectively $20.73 and $13.54, the latter being 65 per cent of the former.

Suggestions on Economical Design and Construction.—Use contour streets. Grade lots and streets at same time. De sign street widths and pavements to meet demands of traffic. Compare cost of reducing grades with cost of pavements suitable for steeper grades. Do not make sidewalks unnecessarily wide. Use combined gutter and curb. Study relative merits of alleys and easements. Study carefully location of utilities. Use combined trenches where suitable. Substitute direct sewer connections for catch basins. Use combination manholes. Connect roof leaders to gutters. Omits storm sewers near summits of streets. Install house connections at one time. Carry house wire services on brackets attached to rear of house.

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*A paper presented Oct. 17 at the joint conference of the American City Planning Institute and the Town Planning Institute of Canada.

Paris Proves the Wisdom of City Planning

The right building of modern cities was first undertaken in France. The French capital, Paris, is the best example of successful city planning and building on earth today, and because it was well planned and well built, it is one of the largest and wealthiest cities of the world.

Paris had its origin in a marsh. In the century before the Christian era, Paris was a little village on a low island in the Seine. About the year 1700, and during the reign of the great king Louis XIV, the plans of the Paris of today were laid. The king called upon the leading architects of his country to plan the city, and they surveyed the territory adjoining the then crowded, dirty and ill-smelling city as the site for the Paris of the future. During the next century these plans were continued, and some of them put in effect. From that time until today, the people of Paris have worked on the plan prepared for Louis XIV., with the result that they have a city that amazes the world by its beauty and attracts to itself a tremendous wealth and trade from all quarters of the world.

Napoleon Bonaparte is honored in the memory of the French people quite as much for what he did for their beloved Paris as he is admired because of his military genius. Napoleon realized that the city, then of 700,000 people, would become the home of two or more millions. He realized, too, the danger to the city and its people from its then crowded condition. He proposed to give Paris, the center under his reign of the wisest government since Roman times, a splendor eclipsing that of any existing city.

Napoleon began a great work of opening up the city. He made almost forgotten plans effective by cutting new streets. Under his direction superb new bridges were constructed across the Seine, and he transformed the banks of the river by building new quays. He built the first sidewalks in Paris, and lighted the streets at night. Napoleon began, too, the erection of great monuments to commemorate the valor and the victories of his armies. Arches and columns which today are famous the world around are among his works.

The successors of Napoleon continued the works he had started, and for 50 years, as the city grew, the public projects continued. In 1853 Baron Georges Eugene Haussmann took charge of the completion of the improvement and beautification of Paris. Still working on the broad lines laid down by the architects of 1700, Haussmann opened up all of the old city of Paris to light and air. He cut new streets here, widened old ones there, tore down hundreds of old structures that beautiful buildings could be brought to view. He placed the railroad stations in a circle about the old center of the city and opened up fine ways of access to them, and particularly he created new diagonal thoroughfares to shorten haulage.

Cleveland Engineering Society Prefers Local Speakers.—The Cleveland Chapter of the American Association of Engineers has given up, temporarily, at least, the plan of having speakers from outside of the organization speak at regular meetings. It has been found by experience that such speakers could bring out only 10 or 15 per cent of the membership, while if some member of the chapter speaks on a subject which is of first hand importance, the attendance is as large as 50 per cent or 70 per cent. The plan that is now followed is to appoint a certain member to talk for a few minutes on a selected subject which is of immediate interest to such men as make up the majority of the chapter membership. After this introductory talk the subject is thrown open for general discussion with a view of getting the opinion of the chapter and taking positive action of some sort.

New Method for Adjusting Earth Excavation and Determining Haul

Every highway engineer who is striving for economy in highway design finds that his greatest problem lies in the adjustment of his grade line so that he can avoid unnecessary earth work. The amount of surfacing which he must use is rather arbitrarily determined by the length of the route selected and is all but independent of the gradients finally adopted. Similarly, the number and the size of the drainage structures are determined, almost entirely, by the location and are quite independent of the gradients used. These, with the earth work, make up the three major portions of the cost of any highway but, differing essentially from the other two in this respect, the quantity of earth work can be modified, to a very marked extent, by modifications in the grade line, no matter what location is chosen. Economy of design, therefore, dictates that the gradients which are finally selected not only meet general engineering requirements, but that, as far as possible, all economies which do not involve a conflict with general engineering principles be adopted. An interesting discussion of a graphic method of adjusting excavation and of determining overhaul is given in the August-September Public Roads by J. W. Ball, Highway Engineer, and C. R Shore, Highway Draftsman, U. S. Bureau of Public Roads. The matter following is abstracted from this discussion. The methods described are believed to be original, but whether original or not, it is felt that their usefulness justifies their presentation at this time and that their careful study and more general adoption by highway engineers will result in noticeable savings in the cost of excavation. On the other hand, it is recognized that these methods are not competent to correct improper location nor do they suffice to determine the most economical general adjustment of the grade line. They do, however, suffice to indicate local changes in grade alignment which are in the interest of economy. The changes worked out may or may not be in keeping with general engineering principles, and where this method is adopted it is, therefore, necessary to caution those who use it that the changes which this method develops as in the interest of economy may have to be rejected as in violation of major engineering principles. An illustration of this fact would be the development, by the use of this method, of the fact that a shorter curve should be adopted at a point where the minimum has already been selected, or that a short adverse grade in a long ascending grade would save excavation. In either case an engineer would hesitate to follow the dictates of economy and should, in fact, reject the information developed as of no value, more important considerations preventing its use.

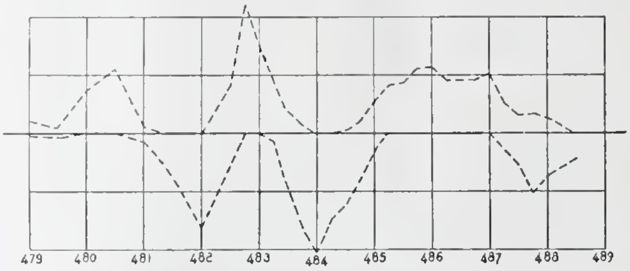


Fig. 1.

These and other cases will occur where the information developed can not be used but they serve simply as an illustration of the general statement that this system is an assistance in the proper adjustment of highway grade lines, not a panacea to be applied for the elimination of excessive costs rightly chargeable to poor location or to improper general assumptions as to the laying in of the grade line. The discussion follows:

The Quantities Diagram.—The "quantities" diagram, as applied to highway design, consists of two curves obtained by connecting the two series of points which result if the stations are platted as abscissas and the corresponding end areas of excavation and embankment, respectively, as ordinates. Excavation is platted positive, and embankment negative. The excavation curve would then always appear above the horizontal axis (or coincident with it wherever there is no excavation), and the embankment curve would appear below the horizontal axis (or coincident with it, where there is no embankment). With end areas platted in square feet and the stations and fractions thereof in linear feet (see Fig. 1), the area included between the horizontal axis and the curve which lies above it represents the volume of excavation, while the area included between the horizontal axis and the curve which lies below it represents embankment, both in cubic feet.

These areas are readily found by a planimeter and by using a horizontal scale of 1 in. to 100 lin. ft. and a vertical scale of 1 in. to 100 sq. ft., 1 sq. in. on the "quantities" diagram represents 10,000 cu. ft. of excavation or of embankment, as the case may be.

This "quantities" diagram furnishes a quick and accurate means of determining the quantities for preliminary estimates, but, more important still, it presents a useful yardage curve to be studied in connection with general grade revisions, since it shows the location and amount of earth work at all points along the line. The curves are particularly useful in locating sections of a highway which are grossly out of balance, for the predominance of cut or of fill over any section of a highway is very noticeable. These curves do not, however, give any indication as to whether the failure to secure a balance is due to a general policy of doing too much cutting or of calling for too much filling or is caused by a failure to make proper use of the maximum grade. These curves simply indicate where a lack of balance exists. The question as to whether this lack of balance is to be corrected at all and, if so, what methods are to be adopted, is one of engineering judgment which can not be assisted by any set formula.

The Excess Area Diagram.—The "excess area" diagram is the algebraic sum of the excavation curve and the embankment curve of the "quantities" diagram. Excavation excess is platted as positive and embankment excess is platted as negative and the line stations are platted along the horizontal axis as before. In this graph the ordinate for each station is in square feet and is the difference in square feet between the excavation included in the end area and the embankmnt included in the end area for that station. This is platted as positive if the excavation exceeds the embankment and as negative if the embankment exceeds the excavation. Where the road is all in cut or all in fill the "excess area" curve will coincide with the quantities curve but where, as in side hill work, cross sections include both cut and fill, the "excess area" curve will fall between the two curves of the quantities diagram. Moreover, wherever the cut and the fill are equal, the "excess area" curve will intersect the horizontal axis, from which it naturally follows that, on a hillside location, where an ideal location would cause the cut along any section to exactly make the fill along that section, the excess area curve will be a straight line coinciding with the horizontal axis. Any deviation from such a location causes the excess area curve to separate from this horizontal axis.

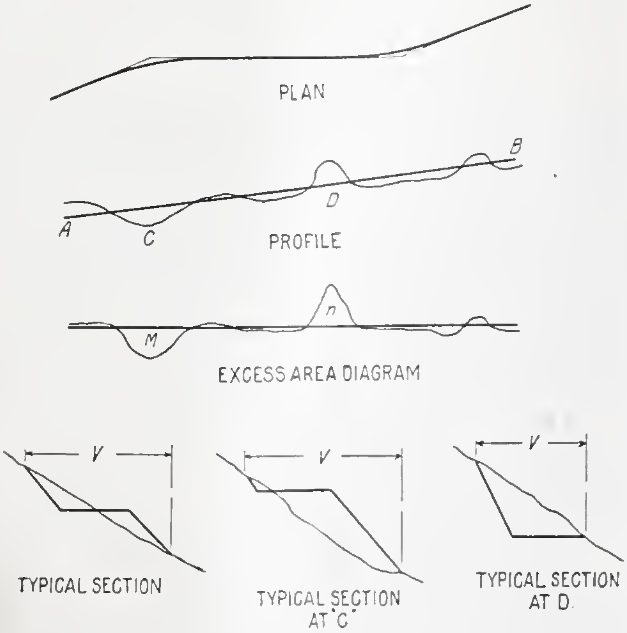
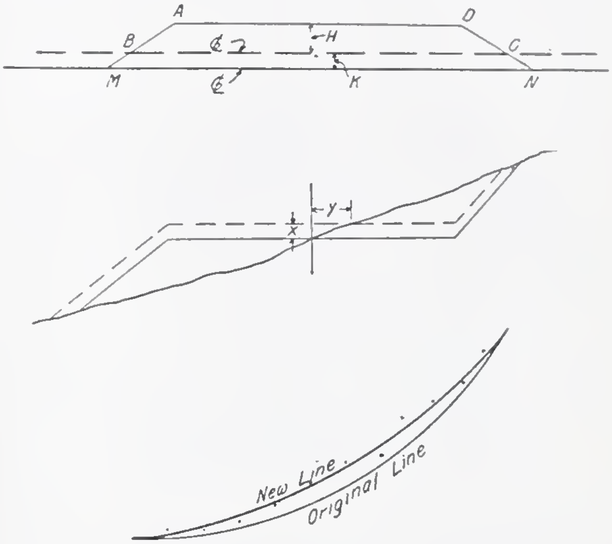


Fig. 2.

The excess area diagram therefore shows to what extent the location of the grade line varies from this ideal line. Moreover, the area below the excess area curve and above the horizontal axis represents the volume of excavation in excess of that required to make the corresponding fill along this portion of the line and the area below the horizontal axis but above the excess area curve represents the volume of embankment which is in excess of that produced by the excavation over that section. The excavation and the embankment on any given length of a project are, then, theoretically balanced when the plus and minus areas on the excess area diagram are equal over this length of the project. The quantity to be hauled is also accurately and clearly shown and the distance of the haul can be closely approximated.



PLAN

Fig. 3.

Whenever an allowance is to be made for shrinkage it is advisable to increase the embankment areas by the customary per cent (which usually varies from 15 to 25 per cent of the volume of embankment in common excavation) before calculating the difference between excavation and embankment. The amount of increase to be used is generally fixed by established rules but may, in the absence of fixed rules, be adjusted according to the judgment of the engineer.

Use of the Excess Area Diagram.—The road location having been made in the usual way, and the end areas from cross sections having been obtained from a tentative grade line, to apply the excess area diagram in the design of the road, first plat the quantities diagram, using for this purpose the information secured from the cross sections for the tentative grade line. Any gross errors in the balance will be shown by the quantities diagram and the first step should be to secure a decision as to their adjustment. If they are to be eliminated the grade line should be relaid and the quantities diagram redrawn until there is some approach to a balance between controlling points. The excess area diagram should then be drawn and the work of refining the grade line may proceed. This refinement of the grade line will involve minor changes in the position of the line; that is, pushing it into or pulling it out of the hill on sidehill work, or minor changes in the established gradient. These will be discussed independently.

Alignment Revisions for Balancing Quantities.—Assuming now a section of sidehill road of profile AB (see Fig. 2) with a typical cross section as S and with the elevations of A and B as fixed or controling points, then naturally the desirable grade line would be unbroken, that is, would show no reverse grades from A to B.

If a location made from A to B on the plan and profile as shown in Fig. 1 results in an excess area diagram as shown in this figure, and if the excavation on the section as a whole is practically in balance it is at once apparent that points C and D vary from the economical location by the excess embankment m at C, and the excess excavation n at D, and that if the balance is preserved the excess excavation at D must be hauled to C. The problem then is to revise the alignment at C and D so that the excess area curve will approach as closely as possible to its most economical position, that is, the horizontal axis, and to do this without disturbing the balance on the section, AB, as a whole, and without introducing any improper gradients.

On a sidehill location, pulling the alignment out of the hill has the same effect on the quantity of earthwork as raising the grade. Similarly shoving the line into the hill has same effect as lowering the grade. If now the effective width of a cross section is defined as the horizontal distance V (see typical cross section Fig. 2) between the intersections of the original ground slope and the ditch slopes, then the result of a change in the elevation of the grade depends upon the effective widths of the cross sections involved.

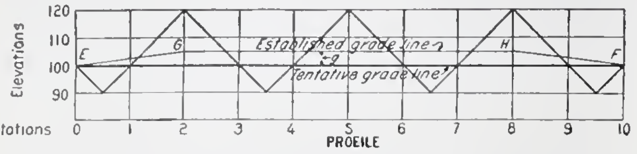


Fig. 4.

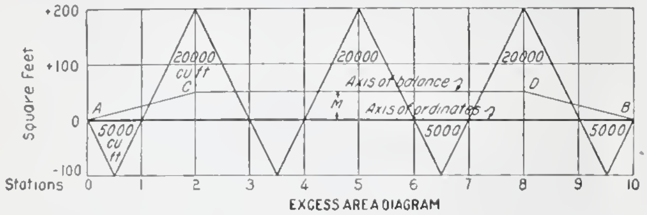


Fig. 5.

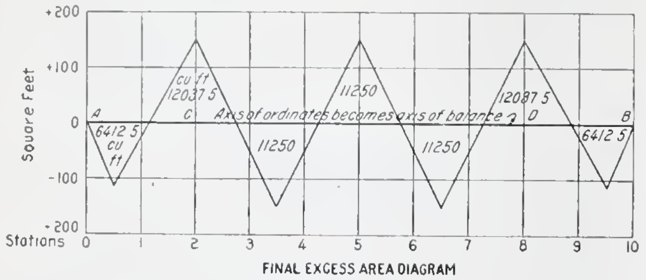


Fig. 6.

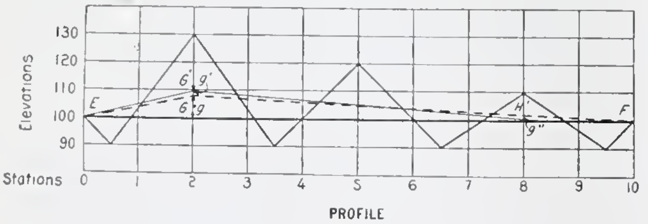


Fig. 7.

Thus (see Fig. 3) assume a fill on level ground. The area of the cross section is $\frac{AD + BC}{2} \times H$. If this fill is increased down by a height Y the area becomes

$$\frac{AD + BC}{2} \times H + \frac{MN + AD}{2} \times Y.$$

The reverse of this holds true if the height of the fill is decreased. This same also holds true if part of the section is in cut and part in fill, the fill being increased by raising the grade line and decreased by lowering the grade line by the average width of the bases times the amount of the change in grade. But AB is the same as V in the type figures, MN is the same as V' and Y the same as g. There results the general deduction that for any change in grade, the change in excess area of the cross section equals $g\frac{(V + V')}{2}$, which is positive when the grade is raised and negative when the grade is lowered. For small changes in grade elevation V' may be assumed as equal to V and the equation there becomes gV. For changes of grade elevations exceeding half of a foot the average effective widths should be determined by scaling the cross sections.

Changes in Center Line Position.—At points such as C and D in Fig. 2 the change required in grade elevations at each cross section, if an economical balance is to be secured is easily computed in feet as will be more clearly brought out later on. However, it is often inadvisable to make adjustments by means of local changes in grade and, on hillside locations, a similar result can be secured by moving the center line a corresponding distance from or into the hill so that the required lowering or raising of the ground surface results. The amount of this lateral movement (see Fig. 3) is easily determined. Raising the grade line reduces the excavation and increases the fill. By an inspection of Fig. 3 it will be clear the primary effect of raising the grade line a distance x is to throw the center line out of the hillside by a distance y. If on the other hand embankment is to be decreased, the line must be pushed into the hill. This distance y may be determined for any cross section by platting on this cross section the change of elevation which has been calculated as necessary to accomplish the desired change in excavation or in embankment and scaling y. To determine the desirable change in the position of the center line over any section of the highway, the y distances are platted as shown in the plan Fig. 3 and a new curve laid which will as nearly as possible average these points.

It is seldom possible to achieve what would theoretically be the most economical location, for in rounding points maximum grades must be considered and excess excavation must be provided to make the embankments in the gullies. Moreover, the closeness of the approximation of the alignment to its most economical location is governed by general conditions as to maximum grade, maximum radius, length of line of sight, etc., but the excess area diagram is of much help in adjusting the grade within the limits imposed by such requements.

Grade Revisions for Balancing Quantities.—Consider a profile as shown in Fig. 4 and for convenience assume a level ground line, and excavation and embankment section 10 ft. wide with vertical slopes. Then the area of the cross section is directly proportional to the depth of the cut or fill, and in this special case the cross-section area is always either (1) all excavation, (2) all embankment, or (3) zero.

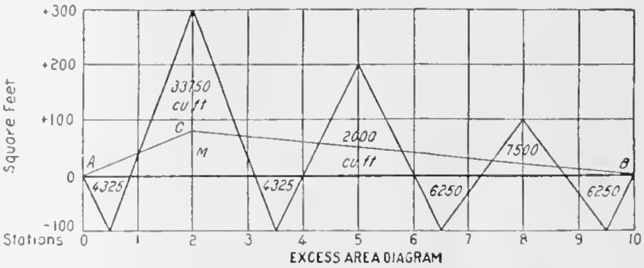


Fig. 8.

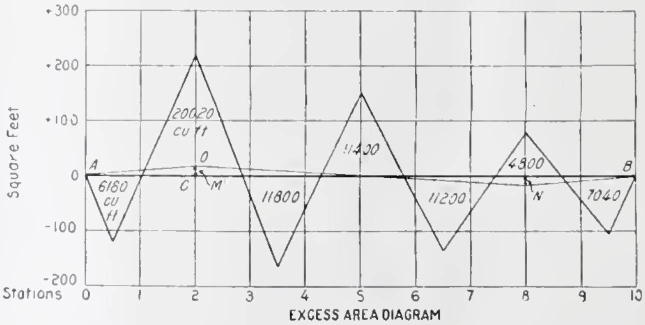


Fig. 9.

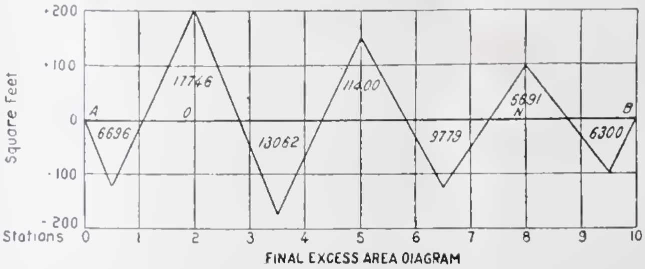


Fig. 10.

With the original grade line as shown at EF in Fig. 4 the excess area diagram is platted as in Fig. 5 and shows that the excess excavation for a 10-ft. width of cross section is 60,000 cu. ft. and the excess embankment 20,000 cu. ft. The balance is, therefore, 40,000 cu. ft., deficient in embankment, no account being taken of shrinkage. Assume that it is desirable to raise the grade line parallel to itself, but that, on account of local conditions, it must be broken at G and H to connect with the former grade at E and F. Let M be the vertical ordinate representing this change as it will appear on the excess area diagram, that is the average required change in the area of cross section in square feet. Then, since $\frac{AB + CD}{2}$ is the average length of the trapezoid ABDC in Fig. 3, to determine the vertical ordinate or its equivalent the required change in cross section, there results the equation

$$M = \frac{40,000}{\frac{AB + DC}{2}} = \frac{40,000}{\frac{1,000 + 600}{2}} = 50$$

which is the average change in cross section required to produce the desired result.

On a cross section 10 ft. wide, as assumed, a change of 50 sq. ft. in end area is secured by a change of 5 ft. in grade elevation. Hence the grade line from G to H, Fig. 4, should be raised 5 ft., the grade EGHF resulting.

After this change in grade line is made, the resulting excess area diagram may be plotted, as in Fig. 6, which is a rectification of Fig. 5 about ACDB, which line thus becomes the new horizontal axis and the quantities are found to be balanced within ordinary working limits of accuracy.

With similar conditions as to vertical slopes and width of cross section Fig. 7 is a profile with a tentative grade line placed at EF, which yields the excess area diagram shown in Fig. 8. The excavation is considerably out of balance. It is desired to balance the quantities by raising the grade line at one point as G. In Fig. 8, ACB illustrates the effect of this change on the corresponding excess area diagram. But

$$M = \frac{\text{Deficiency of balance}}{\frac{AB}{2}}$$

and

$$g = \frac{M}{\text{Average area of cross section.}}$$

Proceeding as before, Fig. 9 is the excess area diagram with the new grade line EGF as the axis. However, this adjustment involves a long haul between station 2 and station 9 + 50 and to further adjust the grade line to eliminate this haul the line of balance of the excess area diagram should be revised. By proceeding as before the excess area diagram (Fig. 9) is modified to show a new balance along AONB and the grade line is revised to EG′H′F in Fig. 7, g′ and g″ being computed as indicated above The excess area diagram may then be plotted again as in Fig. 10, which is a rectification of the excess area diagram about the grade line. EG′H′F, which shows that the quantities are in balance with a minimum haul. When familiar with the method of procedure one makes the first revision from the quantities diagram and the final revision generally without a preliminary trial.

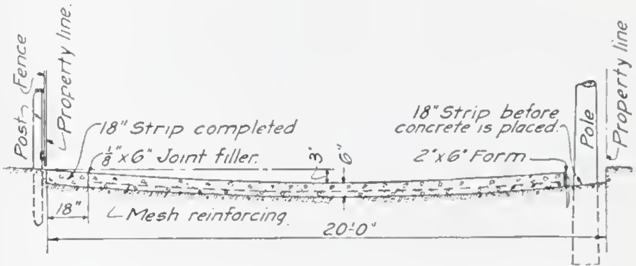
In actual construction, because of the approximation in determining the effective widths of cuts and fills, it is sometimes found that after revision the quantities are still somewhat out of balance. In this case by using two trial excess area diagrams, one can interpolate for the real balance very accurately.

Overhaul of Excavation.—"When the distance between the center of mass of any cut and the center of mass of the corresponding embankment exceeds 1,000 ft., all of the material obtained from the cut and used in the embankment shall be known as 'overhaul excavation,' and the length of overhaul shall be measured as the distance between center of mass of cut and center of mass of fill, minus, 1,000 ft." [From U. S. Bureau of Public Roads, Typical Specifications.] This defines the method by which overhaul shall be calculated in making final payment for overhaul, and where this definition is used it must be adhered to strictly in making final payments to contractors. However, for other purposes, the center of volume of excavation to be hauled and the center of volume of the corresponding embankment may be approximately determined by inspection from the excess area diagram and a close approximation of the overhaul readily calculated.

If it is desired to determine the center of volume of any excess either of embankment or of excavation, the excess excavation or embankment may be divided by vertical lines, and the areas on each side of each line can be measured by a planimeter. In this way an approximate center of volume can be quite rapidly calculated. Overhaul is the distance between the center of volume of the excavation and of the corresponding embankment less the free haul multiplied by the quantity moved. This method is much easier and quicker to apply than that of the mass diagram, and while, as stated above, not legal for computing final estimates, is satisfactory for grade adjustments, estimates, and even for intermediate vouchers.

Method for Simplifying Concrete Alley Paving

In constructing concrete pavement in alleys where buildings and fences are on property lines with telegraph poles within the right of way it is very difficult to secure a true convex or concave surface by the use of hand floats or lutes. This difficulty was overcome by Metzel & O'Hearn, Contractors, in some alley paving laid this year in Covington, Ky. Their methods are described as follows in The Concrete Highway Magazine:



Section of Concrete Paving in Alleys at Covington, Ky.

The alleys were 18 ft. wide, with concave surface having a 3-inch fall from edge to center. A 1:2:3 concrete mixture was used. The concrete was laid 6 in. thick and reinforced with wire mesh.

In an endeavor to improve on the lute method, a 2 by 6-in. form was set up on each side of the alleys 18 in. from the property line. This left 15 ft. between forms, into which space concrete was placed, struck off with template and finished with roller and belt as in regular road construction. The mixer was set up at alley intersections and concrete buggies were used to carry the concrete to where deposited. The 18 in between the edge of this pavement and the buildings or property line provided space for the men to handle strikeboard and belt. After the concrete had been allowed to cure for three days, side forms were removed, a ⅛ by 6-in. expansion joint was placed against the concrete, and the 18-in. space to the property line was then paved. This strip was given a pitch of 1 in. to the foot. By handling the work in this way a true surface was secured and the construction simplified.

Buildings fronting on or extending through to alleys are often not on the property line. They either encroach on city property or are back of the property line. The usual practice is to pave the full width between buildings, disregarding property lines if the buildings are within a few inches one way or the other of the line. However, when the time arrives to build a new building, if the alley is a few inches too wide and the builder desires to occupy his entire holdings, the concrete must be cut away. The cut is likely to be very irregular and may destroy the appearance of the alley at that particular point. By the method of construction described, the 18-in. strip may be removed if necessary, foundations for new buildings constructed and the space remaining between expansion joint and foundation repaved. In this way the main paving is not disturbed. The longitudinal joints, being within 18 in. of the buildings or fences, receive practically no wear

Use of a Self-Computing Level Rod in Highway Surveys

By R. T. BROWN,
Chief of Surveys, State Highway Department of South Carolina.

The principle of the self-computing level rod has been known for years to teachers of engineering and to some practicing engineers of an investigative turn of mind. Details of construction and method of using this type of level rod were described by H. P. Gillette in Engineering News, of Sept. 13, 1900, in a letter to the Editor. This description, with comments, is re-published in Gillette's Earthwork and Its Cost. But due partly to our conservation in following long-used methods, and partly to the fear of introducing new sources of error into levelling operations, we have neglected to take advantage of this time and labor-saving principle.

A brief review of the principle involved gives us the essential features in the construction and use of such a rod.

The ordinary level rod is graduated from the bottom upward; so that of two readings from the same height of instrument the larger reading indicates the lower elevation. Consequently all elevations must be found from their distance below the known elevation of the plane of the telescope, usually designated as the H. I.

The self-computing level rod, on the other hand, is graduated from the top downward so that the greater reading indicates the greater elevation. Therefore, if the level is so situated as to read the exact elevation of a point on which the rod is held it will read 1 ft. more when the rod is held on a point 1 ft. higher. Thus, if the level is set up so as to read 6.15 on a B. M. whose elevation is 6.15 it will read 7.15 on a point 1.00 ft. higher, instead of 5.15 as with the ordinary level rod. If the elevation of the B. M. were 86.15 and the reading thereon were still 6.15 then the reading on a point 1 ft. higher would again be 7.15, while the elevation would be 87.15. Hence by reading the units and fractions (decimals) direct and supplying the tens and hundreds mentally the elevations of all points in range of the length of rod used can be read directly without being referred to the height of instrument at all.

With a plain rod graduated from the top downward it would be impracticable and often impossible to so set up the level as to read the exact known elevation of the point (B. M. or T. P.) on which the road is held when starting. To eliminate this difficulty the graduations are made on a continuous tape or ribbon passing over the rounded ends of the rod, or preferably over rollers inserted in slots near the ends of the rod. Some means must be provided for clamping this tape or ribbon when it is moved into the desired position.

To use the rod the level is set up as usual at any convenient place and the rod held on the B. M. or T. P. whose elevation is previously known. Instead of reading and recording whatever the wire happens to strike, the movable ribbon is moved up or down until the reading corresponds with the feet, tenths, and hundredths of the known elevation of the point. For example, in the second case of the illustration given above the ribbon would be moved until the wire cut 6.15 and then clamped to prevent accidental slipping. The 80 would be supplied when recording the reading, so that it would show 86.15. When held on the point 1 ft. higher, whose elevation is desired, the reading would be 7.15, which would be recorded as 87.15. The ribbon remains clamped while all readings are made from one set-up. When a turning point is selected its elevation is read and recorded, the level carried ahead and set up, and the ribbon again moved until the level reads the elevation of the point, as found just before moving up.

It, of course, takes slightly more time to adjust the ribbon at each backsight than is required to simply read and record a backsight. When it is considered, however, that these elevations will be plotted directly without further computation and that the levelman is not required to lose time in computing the H. I. at each turn to be able to check on previously established bench marks along the way, since he reads at once the elevation of the bench if the work is correct, it will be seen that the time lost in setting the ribbon is regained by eliminating computations.

The chief advantage, however, of this type of rod lies not in its use for simple profile levels but in taking combined cross section and profile levels. It is common experience when taking cross sections, especially on steep side-hill location, that there are numerous cases in which part of the points on possibly several sections can be read, while the others cannot be secured without the use of a hand-level or a new set-up. The use of a hand level wastes time and introduces new opportunities for error. Taking the readings on these points after making a new set-up involves subtracting the readings from a different H. I. than that used for the points first secured on the same sections. This tends to confusion in the plotting and is very likely to lead to error in the sections.

With a self-computing rod, on the other hand, the elevations of some of the points may be read from one set-up, the remainder read at any other set-up from which they can be seen, and the elevations recorded on the line opposite the proper stations. Since no H. I. is recorded or used there is no cause for confusion to the plotter.

This feature makes a rod of this type especially valuable for taking final sections on finished work, since the elevations in the bottom of a cut can be taken from one set-up and those on the banks from an earlier or later set-up and the elevations shown opposite their respective stations.

The writer has used this type of rod for about five years in all kinds of territory and has seen half a dozen engineers change from doubters to advocates of its use. Some of these are university graduates, others came "up from the ranks" through years of experience on railroad surveys. Two of these men would consistently check within 0.03 to the mile on benches previously established with a Philadelphia rod. Recently a levelman with no previous experience with this type of rod ran a line of levels of about 28 miles by this method, taking cross sections at the same time, and checked only 0.32 out between two U. S. G S. bench marks at beginning and end of this distance.

Since the tens must be supplied mentally each time, from knowing the elevation of the preceding T. P., there is always a possibility of a 10 ft. error through carelessness in keeping up with relative elevations of turning points. Since, however, an error of this magnitude is easily detected on the ground and will most certainly be discovered immediately at the next B. M. it is not so serious as a small error due to an incorrect reading on any rod or to incorrect computations of H. I.s and elevations. When such an error is discovered at a B. M. an inspection of the notes will often reveal the point at which it occurred, and the notes can be corrected without re-running, by merely changing the figures in the tens columns.

Rods of this type are now manufactured in convenient and practicable form for transportation and use. The graduations are on a metal ribbon of such width as to provide a good self-reading rod. The tension of the ribbon when in use is adjustable by means of a screw and a screw clamp is provided to hold the ribbon at any desired setting.

Engineers in the 1920 United States Census.—As a result of Engineering Council's request to the director of the census, the national service committee has been successful in effecting a reclassification of engineers so that all technical engineers will be listed as such in the 1920 census separately and distinctly from the non-technical engineers. Thus, the next census will bring an enumeration of all technical engineers together as one unit under the main headings of civil, mechanical, electrical and mining. Architects will also be enumerated separately. It is believed that every professional engineer can, with very little violence to the facts, place himself in one of the broad classes adopted for the 1920 census: civil, mechanical, electrical, mining. With the general cooperation of all engineers along these lines a much better enumeration should result than in any preceding census.

Engineering Council Joins National Chamber of Commerce.—Engineering council has been elected to membership in the Chamber of Commerce of the United States. The organization has appointed as national councillor to represent it in the national chamber and to serve as the connecting link between engineering council and the central organization, Harold W. Buck, of Viele, Blackwell & Buck, Consulting Engineers, New York City, and past-president of the American Institute of Electrical Engineers, and as alternate Irving E. Moultrop, of the Edison Electric Illuminating Company, Boston, member of American Society of Mechanical Engineers and American Institute of Electrical Engineers.

Lot and Block Units for Moderate Priced Houses*

By ARTHUR COLEMAN COMEY,
City Planner, Cambridge, Mass.

It is to be assumed that in the normal case a proper layout of main streets and disposition of public grounds will permit the minor streets to be so arranged as to produce the optimum in block lengths and widths, the latter closely affecting lot depths. Lot widths on the other hand are not controlled to any large degree by other elements in the plan and may, of course, readily be changed at any subsequent time prior to development or actual sales without materially modifying its general relations.

Factors Controlling Width of Lots.—The factors controlling the width of interior lots are, on the one hand, adequate width for the dwelling itself, light and air in its yards and (to a less degree) passage for automobiles; on the other, the cost of utilities in the street, which rise rapidly as lot widths are increased and practically require the minimum adequate width to be the standard, if not the maximum as well, except as topography and other elements in the plan fix certain points and permit somewhat larger lots without increased expense. A house nearly square is the most economical, so that, except where under the spur of high land values lots have been plotted too narrow, the two room deep house is the usual type.

For detached houses, 7 or 8 ft. is the minimum side yard width to assure sufficient light and air at the first story, as well as safety from fire. One side yard should be at least 10 ft. wide to provide space to drive an automobile. The square house is probably the widest that should normally be provided for. The 6-room house may be as small as 22 ft. square, the 7 and 8-room types running up to 26 or 27 ft. The proper standard minimum lot width for detached houses is 40 to 44 ft. Unless 40 ft. can be obtained, semi-detached or row houses should be planned.

For semi-detached houses, 10 ft. is none too wide a side yard for light and air as well as for the passage of automobiles. Such houses need not be over 23 ft. wide and are frequently not over 20 ft. The proper standard minimum lot width for semi-detached houses is 30 to 33 ft. In sections with moderate rentals it is proper to mix detached and semi-detached houses according to any scheme of grouping the city planner and architect may work out. Each pair of semi-detached houses requires 1½ lots of a size suitable for detached houses. In cases, therefore, where it is desirable to plat lots in advance of building, the 40-ft. width, or better, 44 ft., may be used as a standard minimum.

Disadvantages of Mingling Different Types of Houses.—Three reasons prevent the advantageous mingling of row houses with the other two types: An alley is usually required behind the row house, a considerable expense, which constitutes an unnecessary burden if incurred behind houses with side yards and therefore not dependent on alleys; the larger building units are apt to be out of scale with the other types; and in most cases the type of occupancy is different. The row of three houses placed at intersecting streets may be used with semi-detached and detached houses by adding to the rear yard of the middle house an extension 10 to 20 ft. wide, reaching the side street across the rear of the corner lot. The unit of three will require about two lots of the size for detached houses, and therefore fits into a scheme of 40 to 44-ft. lots.

The row house attains practically its full economy with 5, 6 or 7 in a group. Above 9 the inordinate length of the row becomes unpleasant architecturally, and at the same time increases fire risk and steadily decreases ventilation in the block. Such relatively short groups obviously require special lotting. The lot widths for interior houses are controlled absolutely by the design of the house. To secure adequate light and air, row houses should not be more than two rooms deep. The usual plan is one large room across the front and one or two smaller rooms at the back. The proper width for such a house is 18 or 20 ft. The end houses of rows may be put on lots 27 to 30 ft. wide, so that two such end houses of adjacent groups require three of the lots designed for interior houses.

It is difficult to make a lotting scheme which will serve for both row houses and for semi-detached and detached houses. In cases where row houses are anticipated, lotting should accompany the plan for grouping the dwellings instead of preceding it.

Cost of Frontage Important Factor.—While it is generally recognized that 50 ft. is sufficient distance for light and air between the fronts of small houses, and while this same distance is also a sufficient minimum between backs, in practice such shallow lots as these dimensions produce are seldom found necessary owing to the fact that added lot depth does not correspondingly increase the cost of most utilities. It is frontage that is expensive, and rear land must be considered to remain close to the acreage cost of raw land. This is a particularly important factor where topographical conditions or irregular boundaries would involve considerable extra length of streets to produce but few more lots of standard depth, the alternative of fewer and deeper lots with much less street construction being much cheaper and involving only a slight loss in gross selling value.

On all except the main thoroughfares, the needs of traffic are not sufficient to effect the distance between the fronts of houses. In detached house neighborhoods, experience indicates that 20-ft. front yards are not excessive. For semi-detached houses, 15 ft. is found suitable. For row houses, 10 to 15 ft. may usually be provided. A variation in set back not exceeding 5 ft. usually adds to the attractiveness of the street. Unnecessary depth runs up the cost of service lines from the utilities that are placed in the street. If the street line were placed at the building line, as in Washington, D. C., the utility lines might be run close to the houses, thereby saving considerable expenditure necessary under any of the present methods.

Houses of moderate price normally range from 18 to 32 ft. in depth, the vast majority being from 20 to 30 ft. deep, though certain designs for narrow semi-detached houses may require 34 to 35 ft. In the depth of rear yards even more variation occurs, both because their use varies and because it frequently proves to add so little to the cost to make them ample. For detached houses, an ample garden space for a person working elsewhere during the day is 40 by 50 ft. If not so used, this is still not too large for children's play.

On streets of ordinary width, lots for detached houses should normally be planned 90 to 110 ft. deep; for semi-detached houses, 80 to 100 ft.; and for row houses, 70 to 90 ft., including to the centre of alleys where introduced.

Where extreme land values do not preclude, a scheme of lots based on a standard minimum of 40 to 44 ft. by 90 to 100 ft. is proper. In extreme cases, where row houses are certain to come, lots as small as 16 to 18 ft. by 70 ft. may be necessary, but intermediate widths so common in most of our cities are not easily adapted to modern housing standards.

The Corner Lot.—The best size for corner lots in cases where practically all the houses are to face one set of roughly parallel streets may be fixed as ranging from the same width to 5 ft. wider than corresponding interior lots, and approximately the same depth.

With houses fronting on all streets, to secure the maximum salable frontage and the least interruption to the architectural motive along each street and around the corner, the corner lot is best made approximately square. It should be equal in area to the corresponding interior lots. A somewhat large square corner lot may be cut diagonally in two, and a pair of semi-detached houses set across it, though this expedient is not always pleasant. It is not apt to be a good plan to attempt to crowd houses at a street intersection and still give sufficient square feet of rear yard space by violent skewing of irregularity in lot boundaries. Acute interior lot corners should be particularly avoided. Lot lines should usually be run back at least 40 ft. to a point not less than 5 ft. behind the house, approximately at right angles to the street.

Block Widths and Lengths.—Block widths are normally twice lot depths, though many irregular blocks are bound to be platted, especially in layouts on rough or peculiarly shaped land, to economize in construction cost and in land used for streets.

Block lengths are controlled by the needs of traffic, both vehicular and pedestrian, and by factors of safety. Experience shows that in residential areas, blocks 600 to 700 ft. long cause little dissatisfaction. Shorter blocks are wasteful of land in cross streets. Blocks longer than 800 ft. are found to cause undue detours in going from one side to the other. This is more noticeable in the case of foot traffic than the modern automobile. Inasmuch as adequate footways require but one-sixth the space of cross streets, and even less proportionate construction cost, their use midway across blocks of lengths up to 1,200 ft. is permissible, particularly in districts with steep slopes, making connecting streets expensive. In areas designed with deep courts and blind streets only partially cutting up the blocks, if each such court and street has a path leading from it across the block, most of its disadvantages will disappear, though it will still be less easily policed or protected in case of fire than regular blocks.

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*Paper read Oct. 19th, at joint meeting of the American City Planning Institute and the Town Planning Institute of Canada.

While variations to the ordinary block and lot system which do not easily conform to rule have hitherto seldom been laid out, the increased attractiveness attending their use in a reasonable number of instances demands that the opportunity be not closed by rigid standards. As they are apt to be integral parts of the group designs for the actual houses, their layout cannot be determined until the building program is adopted. Where interesting variations are not anticipated, the minimum standard of blocks, 180 to 200 ft. by 600 to 800 ft., with lots 40 to 44 ft. wide, is more apt than any other to be adapted to the future needs of a neighborhood.

Rules for the Establishment of Street Widths and Their Subdivisions*

By B. A. HALDEMAN.

Advisory Engineer, Zoning Commission, Philadelphia, Pa.

Streets should be divided into the following four classes, based upon their immediate and future purpose and service: Main, secondary, minor and special service streets.

Main streets will form the principal routes for the immediate or future use of large volumes of mixed traffic moving between important centers within a community or from community to community.

Secondard streets will be those of lesser traffic importance, supplementing the main streets and serving to distribute mixed traffic to and from the latter and between centers of lesser importance.

Minor streets will be those laid out for purely local traffic use or to facilitate the subdivision or development of property.

Special service streets will be those designed and laid out for special purposes and restricted to special uses.

The location, width and subdivision, and also the grade, of main and secondary streets should be based upon their present and future value as traffic carriers. They will form the primary net of the street system and should be planned in advance of urban improvements as the controlling elements in the general development of the transportation and other circulatory facilities of the city and the adjacent region, and consideration should be had in their layout for the economic development of those facilities. At least a primary scheme of zoning for use should precede or accompany their layout.

Certain types of special service streets, particularly those designed to connect the units of a park system, should be laid out coincident with the traffic net.

With the net of main and secondary streets established, the areas lying between them may be subdivided by such system of minor or special service streets as may best serve the development of each particular area.

The width of a street shall be understood in all cases to mean the distance between the bounding property lines.

The width of main and secondary streets should be such as will adequately accommodate such classes and such volumes of traffic as are likely to be put upon them after the territory or region they serve shall be fully developed.

The width of minor streets should be such as will adequately care for local travel and service of abutting property.

As special service streets will be designed to serve special and particular uses, any attempt to standardize their widths would be futile.

Recommended widths are as follows:

Main streets	108, 128 or 148 ft.
Secondary streets	60 or 80 ft.
Minor streets	12, 20, 40 or 50 ft.
Special service streets	Variable.

In cities and regions where the laying out of any considerable number of streets of a greater width than 80 ft. would be unwise, it is recommended that streets exceeding that width be placed in the special service class, the "secondary streets" classification eliminated, and the 60 and 80 ft. wide ones classed as "main streets."

The unit width for a line of vehicles shall be 8 ft.

The unit width for a line of pedestrians shall be 2 ft.

The so-called "elastic" method should be employed in establishing and increasing the widths of subdivisions.

The roadway width of a street shall be the distance between curb lines, or between the centers of the gutters where there are no curbs.

No roadway for a single line of vehicles should be less than 8 ft. or more than 10 ft. wide.

Roadways to accommodate two lines of vehicles should be 20 ft. wide except that such roadways in minor and special service streets may be 16 or 18 ft. wide.

Roadways to accommodate three lines of vehicles should be 26 ft. wide.

Roadways to accommodate four lines of vehicles should be 36 ft. wide.

Any increase beyond a roadway width of 36 ft. should be made by adding an 8-ft. unit for each additional line of vehicles to be accommodated. Where the street is, or will be, occupied by street railway tracks, the unit should be undivided, but where there will be no tracks, the unit may be divided.

The minimum width of the space between the property line and the curb line, including width of the curb, should be as follows:

On streets 40 ft. wide	11 ft.
On streets 50 or 60 ft. wide	12 ft.
On streets 80 ft. wide	14 ft.
On streets more than 80 ft. wide	18 ft.

The width of the paved footway on any street should not be less than 4 ft. Increases beyond that width should be by 2-ft. units or multiples thereof.

The planting strip between the property line and the nearest edge of the paved footway should not be less than 1 ft. wide on a 40-ft. wide street, or less than 2 ft. on a street of greater width.

The width of the planting strip between the curb line and the nearest edge of the paved footway, including the width of the curb, should in no event be less than 4 ft. in a street 60 ft. or less in width, or less than 6 ft., in a street of greater width than 60 ft.

Trees should be planted in such locations that they will not be disturbed by, or obstruct, any subsequent change in the curbs or paving.

Where dual roadways are laid, separated by a planting strip, the latter may be of variable width and the curbs adjacent to the sidewalk should be set in their permanent locations.

Where a central reservation for street railway tracks is established it should be at least 20 ft. wide.

The following are suggested typical widths and arrangements of cross-section subdivisions. (Figures indicate widths in feet)·

	40-ft. streets.			50-ft. streets.			60-ft. streets.			80-ft. streets.		
	a	b	c	a	b	c	a	b	c	a	b	c
Planting strip	1	1	1	2	2	2	2	2	2	2	2	2
Paved footway	4	6	4	4	4	6	4	4	6	4	6	6
Planting strip	6	4	5	9	6	4	14	11	4	21	14	6
Roadway	18	18	20	20	26	26	20	26	36	26	36	52
Planting strip	6	4	5	9	6	4	14	11	4	21	14	6
Paved footway	4	6	4	4	4	6	4	4	6	4	6	6
Planting strip	1	1	1	2	2	2	2	2	2	2	2	2
	40	40	40	50	50	50	60	60	60	80	80	80

	108-ft. streets.			128-ft. streets.			148-ft streets.			
	a	b	c	a	b	c	a	b	c	d
Planting strip	6	4	2	6	4	2	6	4	2	2
Paved footway	4	6	8	4	6	8	4	6	8	8
Planting strip	8	8	8	8	8	8	8	8	8	8
Roadway	20	26	26	20	26	36	20	26	36	44
Reservation	32	20	20	52	40	20	72	60	40	24
Roadway	20	26	26	20	26	36	20	26	36	44
Planting strip	8	8	8	8	8	8	8	8	8	8
Paved footway	4	6	8	4	6	8	4	6	8	8
Planting strip	6	4	2	6	4	2	6	4	2	2
	108	108	108	128	128	128	148	148	148	148

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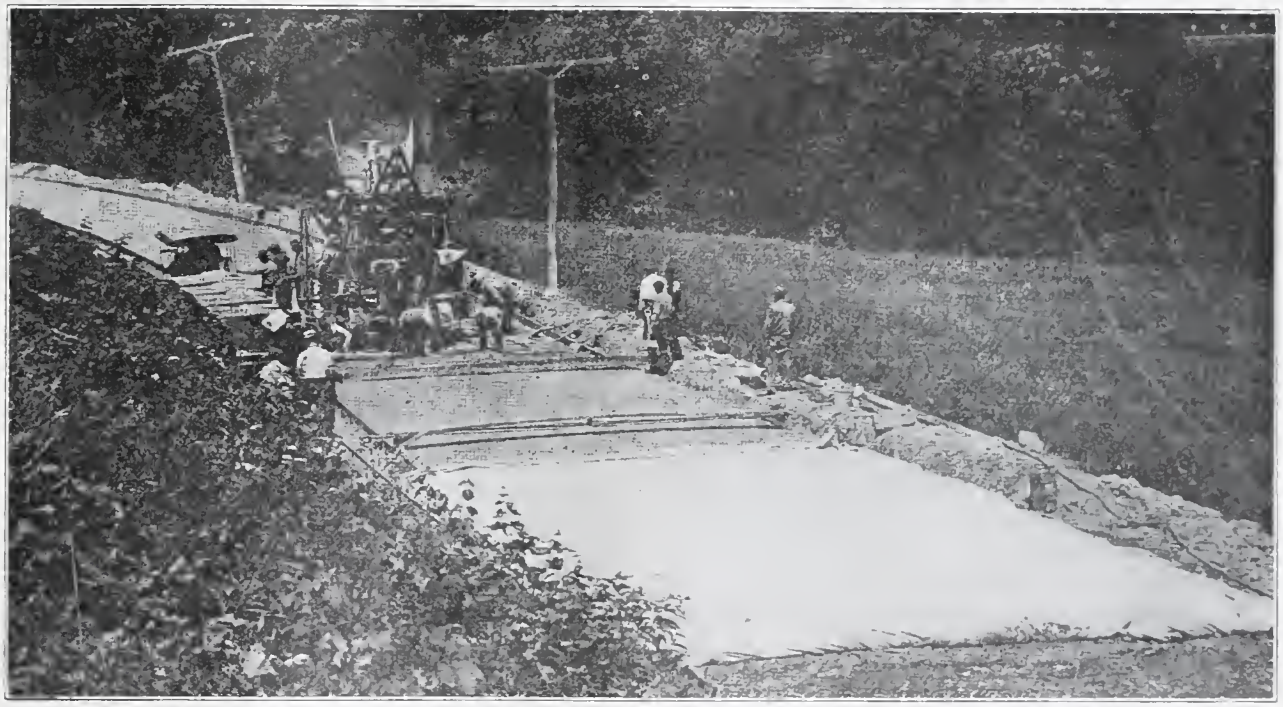
*A report presented Oct. 17 at joint conference of the American City Planning Institute and the Town Planning Institute of Canada.

Effective Use of Machinery in Concrete Road Construction

An excellent example of the effective use of modern road building machinery is afforded by the construction operations on the Federal Aid highway now being built between Morten's Creek and Bangor, Pa. This section is 5.45 miles in length and was let at a contract price of approximately $320,000. The concrete surfacing is 18 ft. wide, 8 in. thick at the center and 6 in. thick at the edges. A 1:2:3 mix is employed.

Light jack hammer drills are used in all rock work. The earth excavation is handled by a steam shovel.

The concrete materials are delivered by rail on the siding. They are unloaded from cars by a locomotive crane, operating a clamshell bucket, and dumped into material bins.



General View of Mixing Plant, Showing Also Method of Protecting Newly Placed Concrete, the Earth Covered Pavement Appearing in the Foreground and the Canvas Covered Slab, Just Laid, Immediately Beyond.

To provide the necessary water for the locomotive crane an old tank wagon was mounted on a platform, a hydraulic ram set in a nearby creek, and the two connected by a pipe line. Since that day, and without further attention, this makeshift tank has never been short of water.

A light industrial track, laid on a gravity grade, runs under the hoppers, which are so built that six buckets can be loaded at once, the operation being carried on as follows:

The engine delivers a train at the top of the gravity track. Six cars are then cut loose and moved by hand so that the first bucket of each is under its stone hopper. The hopper is then opened and the stone compartment of the first bucket on the car is filled. The 6 cars are then moved forward till the second bucket comes under the chutes and the stone compartments in these buckets are filled. The 6 cars are again shoved forward and placed under the 6 sand chutes. In two operations the 12 sand compartments are filled and the cars are then pushed on to the 3 cement chutes where the cement compartments are filled. The whole operation uses 9 men and filling 6 cars (12 full charges for the mixer) takes about five minutes.

In the meantime the engine has picked up another string of the cars, this string having been loaded while the engine was at the mixer, and starts for the mixer. Near the mixer there is a switch where this train lies till the mixer has handled the material delivered to it by the alternate train. When this alternate train pulls out, the first train pulls in with its load and lies at the mixer until its load is used up. In this way two engines handling three strings of cars can keep a large mixer operating at full capacity up to a distance of about 6 miles between mixer and loading bins and on a good track can be operated over grades of 6 to 8 per cent.

The concreting was started in July and the mixing plant was in operation for 30 days out of the first 31 working days. During this time it averaged 240 ft. of 1:2:3 concrete pavement, 18 ft. wide and average of 7.33 in. thick The working force consisted of 8 men on the mixer, 6 men on the material piles and 4 men on the train.

How Drivers Can Help Maintain Good Roads

Drivers can do much for the maintenance of good roads declares Alfred F. Masury chief engineer of the International Motor Co., manufacturer of Mack trucks.

Did you ever notice, asked Mr. Masury, in going up a hill, particularly one paved with asphaltic concrete, that the surface on the right hand side of the road is wavy and rough, while that on the left hand side is smooth? The reason is this: The extra traction required to climb the hill wears and tears the surface, while there is little or no traction down hill.

Another thing, the right hand track of the road in either direction is the one which is worn most This is because of the arched surface of the road which throws the greater weight and strain on the right hand side of the vehicle and consequently the right hand side of the roadway. Truck builders and wagon makers have even adjusted their axles and springs so as to withstand the greater strain on the right hand side of the vehicle.

The custom of arching the roadways was formed in the early days of road making when dirt and porous-surfaced roads were the ones mostly in use, and it was necessary to give sufficient pitch to the surface of the roadway to drain off the water and prevent it from penetrating the surface of the road to soften and weaken the roadbed. With modern watertight surfaces, the necessity for arched roads does not exist and engineers are designing roads with very slight pitch.

Drivers can prevent wear to the surfaces of the roads and even improve their conditions, if instead of driving in one track or on the edge of the road, they will drive over the middle and other less used parts of the road when traffic permits. The one thing that is fatal above all things to road surfaces, whether dirt or paved, is driving in tracks, which subjects one small part of the road surface to all the traffic and damage that the whole road accommodates. Traffic should be evenly distributed over the entire surface of the road, and a little thoughtfulness and care in this respect on the part of drivers will do much to add to the permanence and excellence of our roadways.

General Principles of Road Administration*

By R. W. ACTON,
County Engineer, St. Louis County, Minnesota.

Highway administration consists of three controlling elements: the political, the economic, and the art of road building and maintenance. These elements are so intricately interlocked that to consider any one of them independently of the others, will result in a failure to appreciate the very first principles of road administration.

Analyze the political element. Every individual who owns property pays a direct road tax. Nearly every individual must use the highways. Outside of our public school system, nothing comes in closer contact with the public. Thus, being so close to the public pulse, is there small wonder that it is a fruitful source of political propaganda? No greater opportunity offers itself to exhibit the inherent selfishness of human nature, and with it the narrow, petty vanities and ignorance of the individual. Lack of interest, lack of knowledge relative to actual conditions, and failure to squarely face the situation by the public, tended for a time to permit a political reaction, which obviously blocked progressive administration. But the fact cannot be disputed that when the majority of the public become thoroughly informed upon the subject, they inevitably take a stand for what is right. It is therefore up to highway officials and engineers to study the highway problems in the perspective, as well as in detail, and give a straightforward report of their findings and conclusions.

The economic side of highway administration, interwoven with the political, absolutely governs final results. Practically all revenues collected for construction and maintenance of roads are derived from direct taxation. The return is both direct and indirect, but more often accepted as indirect. Individually, we petition and accept a direct assessment for drainage, sidewalk and street improvements. The improvement is either on or adjacent to our property; and we acquire a direct ownership for something for which we are making payment. On the other hand, the individual pays his road tax into a fund and becomes a small stockholder of property owned exclusively by the public. Instinctively there is a demand for dividends and returns, not always in proportion to the investment.

In recent years road taxes were largely levied and expended locally. With the growth of our centers of population, and the general utility of the motor car, there came a demand for trunk line roads. Obviously, there were large districts of low valuation, which could not meet these demands. This has resulted in increasing the obligation for the county unit, the acceptance of an obligation by the state, and very recently, by the Federal Government.

There are, therefore, four administrative and tax levying bodies, i. e., the township, county, state and Federal governments. The working principles of these organizations are perfectly sound, based on the theory that the township shall provide for its local needs, the county to provide for main roads connecting centers of population within the county, the state provide for inter-county roads and main state trunk highways, with the Federal government applying its funds to highways of national character.

Simple and reasonable as this appears for a satisfactory enonomic working plan for highway administration, and in the face of the fact that Europe's magnificent system of highways was made possible by this method, we have not been willing to accept the principles, except in part. The real condition is that we have rather tended, as a matter of policy, to compromise to county aid, state aid, and Federal aid, with certain legal restrictions to prevent the "pork barrel." State, Federal and county aid has become such a fixed custom with us that naturally the same procedure followed in the distribution of road funds. The outstanding features, however, are that the attempt is too often made to draw on this aid for improvement of a strictly local nature wherein the maximum benefits are not returned to the majority of the taxpayers.

Distribution of Cost According to Benefits.—It is unreasonable to presume that for the best results in the end, Federal funds should be expended on other than roads of national importance. States of large valuation should assist financially in the improvement of national roads through states of large areas and low valuation. The same relationship should hold between state and county, and thence on down between county and township.

We may as well clearly face the situation that money cannot be drawn from the blue sky for road improvements; that each locality to the last individual, who is desirous of having good roads must be willing to pay the cost; and that there must be a reasonable clearly defined classification of highways upon which township, county, state and Federal government must assume a financial responsibility. Until the public is willing to recognize this primary fundamental principle in the economics of road administration, we must work under a handicap.

It is very reasonable to assume that in the near future we will see as much time, thought, and study devoted to road economics as to the constructive features, both of which have been magnified by the intensified motor and motor-truck traffic of the past three years. During the past fiscal year, the expenditures in the automobile industry alone amounted to approximately $1,000,000,000. The office of public roads at Washington report that the total expenditures for highways of all classes for the same period amounted to $300,000,000. Inasmuch as the auto and auto-truck are but one class of vehicle which the roads must carry, we have reason to question whether the correct proportion is being held between the expenditures that are being made for the rolling stock that goes on to the road as compared to expenditures for highway construction and maintenance. This question is especially pertinent, considering that the country is still in a development stage, and must need to be constantly facing a demand for more road mileage.

No expense has been spared to perfect a high-power economically operated motor car. In addition to this, the perfecting of the motor-truck has advanced more rapidly in the past two years than would have been reasonably expected in ten years during ordinary times.

Equitable Form of Taxation Must Be Evolved.—It is obvious that a progressive readjustment must be made in highway economics, which shall determine the manner and methods of financing our highways. This must involve an equitable form of taxation, based upon a comprehensive classified road system which will provide for the needs, from the congested trunk line to the last feeder of the actual settler or farmer. This must involve, either by annual levy or bond issue, the raising of sufficient funds to provide the economic type of construction for the various road classifications, to which sufficient funds must be provided for adequate maintenance of the same. This involves, in detail, the formation of a budget of expenditures, in order that an equitable tax may be levied; that an equitable distribution of the funds may be made to the various road classifications; and that a definite working program may be laid out.

Rapid strides have already been made in bringing roads into a classified system. The various state highway departments, in conjunction with the Federal government, have taken the initiative in this matter, and the county units are rapidly dropping into line. The state of Minnesota has probably taken the lead in this respect in the Northwest, having developed a 10,000-mile state trunk road system out of a total mileage in the state of close to 100,000 miles. In addition to this, a Federal road mileage has been designated which incorporates approximately one-half of the designated state trunk road system. Numerous counties are classifying their roads, laying out definite building programs covering a period of several years, and making up their annual budgets in a manner to facilitate the work.

Politically, we are opposed to the budget system in the raising and expending of public funds, as is evidenced by the action of our national legislative body. All political parties, in their platforms, advocate the system, but fail to bring forth legislation in the matter. Nevertheless, the demand for efficiency, results, and taxation limitations, will automatically force this system in road administration, and with it, must then necessarily come the working program and the classified road system.

While our state legislature must be called upon to determine the equitable form of taxation for the construction and maintenance of our highways, it is obvious that our highway officials and engineers must eventually work out the details of a solution for presentation to them. In general, outside of a varying registration motor tax, practically all funds raised within the state are derived from a general property tax, and while highway expenditures were low, little attention was given to the matter. Unquestionably, however, with the increased expense in highway construction and maintenance in order to meet traffic demands, the carrying of the total cost as a general property tax is decidedly unfair. There seems to be no valid reason why a wheelage tax, based on horsepower and weight per inch of tire width should not be suitable. While not in a position to give definite figures, we have come to the conclusion that the highway wear and tear, per vehicle per mile, can be readily determined as the tire cost per mile on a motor car.

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*From a paper presented before the Engineers' Club of Northern Minnesota.

It is my opinion that we have nearly reached the limit on property tax, except by direct assessment, until some provision has been made to exhaust the possibilities of the wheelage tax.

In the Northwest, Michigan and Illinois have gone into this subject exhaustively, and are raising substantial levies under this form of tax. Illinois has gone so far as to lay out a 5,000-mile system of trunk roads to be constructed at a cost of $60,000,000, and financed by a bond issue, the interest and principal of which is to be paid from a wheelage tax. This illustrates the extent to which the possibilities of a wheelage tax may be equitably carried out.

Another form of equitable taxation is the direct assessment. This is especially applicable when the highways are being constructed under a bond issue. Admitting that every piece of land cannot have a surfaced road built around it at public expense, we must admit the fact that lands lying directly adjacent to a surfaced road obtain a special benefit that cannot be obtained by all lands within the territory, and are therefore reasonably subject to special assessment.

In this state, under what was commonly known as the Elwell law, highways estimated at over seven million dollars were petitioned for, of which approximately 1,100 miles were constructed at a cost of $3,500,000. This law assessed one-fourth of the cost of the improvement to specially benefited property. On high class road improvement, I believe the percentage is too high, but certainly a portion paid by direct assessment is an equitable tax. This law was repealed, but not due to objection with reference to the assessment features, which I know, from personal knowledge, were not unpopular. The actual repeal was forced by objections to the bonding features of the law. Unquestionably, the law required constructive amendment, rather than repeal.

It is my opinion that not only an equitable but a popular form of road levy may be devised which would involve direct property tax, wheelage tax, and special assessment.

Road Building Under a Bond Issue.—The question of financing highway construction invariably brings forth the question of building under a bond issue. That subject in itself, could not be entirely covered in an evening's discussion. In general, the construction of roads under a short-time bond issue (not exceeding ten years), while not entirely successful, has warranted the experiment due primarily to the educational benefits in showing the economy of concentrated work. The experience in this state, which from the reports of the department of roads at Washington is generally duplicated in other states, is that the issues are seldom sufficient to cover the contemplated work.

It has been our experience, that after a road is petitioned for under bond-issue proceedings, and the engineer has made a careful estimate of the cost, that the figures generally stagger the promoters of the project to the extent that the project either falls through or the engineer is ordered to reduce his estimate on revised specifications. This is an easy compromise for the promoters, for when the bond issue has gone through at the reduced figures they immediately forget the revised specifications. Obviously, there is general dissatisfaction when the work is completed.

Bond issues for surfaced roads should certainly not be carried over a longer period than the life of the road surface. Some of the Eastern states, which have gone into long term bond issues of 40 to 50 years, have had the misfortune to pay for pavements, the life of which did not exceed seven to nine years. It is generally conceded that bond issues for long-time periods should cover only the more permanent portion of highway construction; i. e., the subgrade grade work, including excavation and permanent bridges and culverts. The financing of road surfaces should be raised by issue of from five years up to not exceeding 15 years, depending upon the type of pavement.

Precautions for Concrete Pavement Construction in Cold Weather

Sometimes early cold weather, accompanied by freezing temperatures, finds the contractor on concrete pavement work with a small stretch of his contract uncompleted. Under these conditions he must decide whether to lay off his crew for the winter, resulting in the loss from tied up capital and a handicap on early spring work because of an uncompleted contract, or to provide means for completing the contract at once. The latter is usually found less expensive in the end where only a small yardage is involved. Construction of concrete pavements during extremely cold weather is not recommended, but often the best interests of the public can be served and the contractor's profit protected by taking measures to insure the successful completion of the work. The precautions that should be taken under these conditions are described in a bulletin issued recently by the Portland Cement Association.

Principles to Be Observed.—Low temperatures retard while warmth tends to accelerate the initial hardening of concrete. To insure the success of concrete pavement work done during cold weather, it is therefore necessary to heat the aggregates and the mixing water so that the concrete, when deposited on the subgrade, will have a mass temperature of not less than 80° F.

Immediately after the concrete has been placed and finished, it must be protected during the curing period by hay, straw or canvas. By stretching canvas on light frames to make shelters that will enclose the newly finished sections of pavement, the temperature within such an enclosure may be maintained at a point which will facilitate hardening of the concrete during the time required for that process.

Heating Aggregates.—Many concrete pavement contracts are now supplied with aggregates from a central plant, the materials being conveyed from this plant to the mixer by industrial railway or motor truck. If the yardage to be completed during cold weather is relatively large, it will probably pay to install rotary heaters for aggregates. These may be of the same type as are used for heating aggregates for asphalt pavement mixtures, although it may be necessary to operate them at a higher speed than is customary for asphalt pavement work, in order to turn out the volume of heated sand and stone required for concrete pavement operations. If rotary heaters are not practicable, it is possible to heat both sand and stone rapidly by jets of live steam directed into the piles as the materials are loaded into the cars or trucks conveying them to the mixer. If the distance from loading plant to mixer is great, it may be necessary to arrange for heating after the materials have reached the mixer. These are details which must be worked out in accordance with the circumstances and requirements of each particular job. Where aggregates are delivered and stored upon the subgrade ahead of the mixer, it is possible to heat the piles of sand and stone by live steam jets or pipe heaters. The latter usually consist of sections of steel pipe, like a boiler smokestack, placed on the ground and upon which the aggregates are piled. Fires are built inside the pipe, using any available fuel, and the heat is thus distributed throughout the pile of aggregates. With this method it is sometimes necessary to guard against heating aggregates to too high a temperature, as some materials, such as flints and quartz gravels, may be injured by high heat.

Heating Mixing Water.—The most convenient methods for heating mixing water involve the use of portable furnaces or braziers, which will burn coal, wood or coke, and which contain coils around which the fire is built. These coils are connected to the mixer water supply line at any convenient point.

Protection of Pavement During Curing Period.—After the concrete has been laid, it is of vital importance that its temperature be maintained as much above 45° F. as possible, for at least 10 days, in order that the concrete may attain the required strength. Immediate protection must be given after finishing, so that the warmth introduced by heating the aggregates and mixing water will be retained as long as possible.

A canvas protection may be spread over a light frame and the required temperature maintained within by supplying artificial heat with lighted lanterns, salamanders or steam coils, depending upon the atmospheric temperatures outside the shelter and upon the tightness of the canvas protection. If snow or cold storms may be expected, it may be best to cover the newly placed concrete with a foot or more of straw, which in turn should be covered with canvas. Earth banked upon the edges of the canvas will help hold it in position and will also help to keep out much cold air and prevent the covering from being blown away. Such protection will keep out frost for many weeks, especially if snow should fall on the canvas and the temperature does not go too far below the freezing point. Sawdust is sometimes used for protecting pavements from cold, but care should be taken not to use a sawdust which will stain the pavement surface. If it is important to have the pavement ready for traffic at the earliest possible date, it will probably be best to use a light framework covered with canvas and maintain the required temperature within this enclosure to insure proper early hardening.

Unless the foregoing precautions can be taken for protection during the curing period, the concrete should not be used for traffic until the next spring, following a period of at least 30 days of mild weather.

Stable manure should never be used as a protective covering for fresh concrete. It will cause permanent staining of the surface and acids may develop in the process of decomposition that are likely to cause a pitting and scaling of the green concrete.

Use of Chemicals to Accelerate Hardening of Concrete.—Use of salt and other chemicals to lower the freezing point of water or chemicals to accelerate the hardening of the concrete is not advocated where the protective measures described can be applied. The following suggestions regarding the use of chemicals may be of assistance in some cases:

The only chemical recommended as an addition to the mixing water is calcium chloride. This material possesses the property of lowering the freezing point of water and accelerating the setting of cement. It is used by being dissolved in the mixing water. It is generally sold in crystal form and is readily soluble in water. If used in quantities of about 3 per cent by weight of the mixing water, it will enable placing the concrete when the temperature is slightly below freezing, with little danger of injury. When the proper mixing water ratio of more than 5½ to 6 gal. of water is used for each sack of cement in a standard paving mixture of 1:2:3 proportions, the quantity of calcium chloride to use will be 1.5 lb. per sack of cement. This amount will correspond closely to 3 per cent by weight of the total mixing water.

The use of common salt (sodium chloride) in concrete mixtures is not recommended. While salt has the property of lowering the freezing point of water, it also seriously retards the setting of cement, which, of course, is exactly opposite to the condition sought in cold weather concreting.

Protection to Workmen During Cold Weather and Housing Equipment.—The contractor can increase the efficiency of his workmen and add to their output by providing them with protection from the elements during severe weather. This is particularly true of those workmen who must stand for long periods comparatively inactive and exposed to the wind. The concrete mixer should be provided with a shelter which will protect the engineer and fireman while working. The men who handle cement at the mixer are particularly exposed and do not have the advantage of those men who work with warm materials, as it is unnecessary to warm the cement. The finishers should be provided with a place where their tools can be warmed from time to time, and with a convenient shelter, where they can warm their hands and bodies when not actively working on the pavement. A little attention to these details, which contribute greatly to the comfort and efficiency of the workmen, will return many times their cost in the form of increased daily production.

Ohio Has $14,500,000 of Road Contracts Under Way.—According to a report of A. R. Taylor, State Highway Commissioner, Ohio has contracts under way covering 500 miles of highway. The total cost will be about $14,500,000. The previous high total was 371 miles, in 1916. Federal aid of $10,205,625 has been granted for this and next year and 1921. The state appropriation for main market roads for the two years ending June 30, 1921, is $2,255,500. And for the intercounty roads for the same period $6,466,500. A sum of $5,000,000 from auto license fees will be available for maintenance and repair purposes. This makes a total sum of $23,927,625, for the state highway system, not including county or local roads, built and maintained from local levies. Sixty-six counties will vote on special local levies next month.

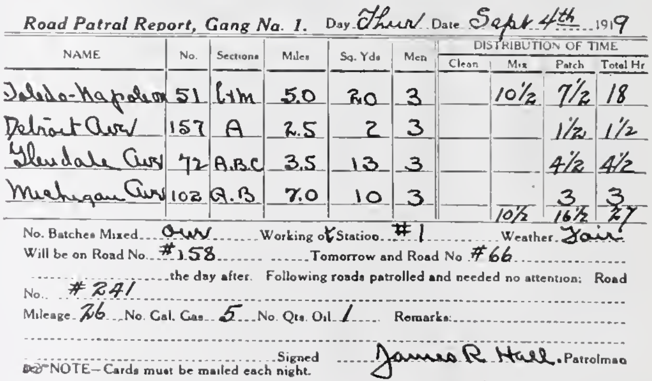
Gang Patrol System for Maintenance of Lucas County, Ohio, Highways

Patrol gangs working from central stations have proved very effective in maintaining the highway system of Lucas county, Ohio. The plan which was worked out by Cecil L. Rood, County Surveyor, is described in the November issue of The Highway Magazine, to which we are indebted for the information in this article. The road system is divided into five districts, each of which has a patrol station near its center. These patrol stations, all located at railroad points of delivery, are as follows:

Standard Patrol Station.

No. 1.	Maumee	42.4	miles of road in district
No. 2.	Whitehouse	43.8	miles of road in district
No. 3.	Reynolds Corner	71.9	miles of road in district
No. 4.	D., T. & I. crossing	46.7	miles of road in district
No. 5.	Booth	63.8	miles of road in district
	Total	268.6	miles of road in district

The illustration shows one of the standard patrol stations, which was erected at a cost of $750. Each station has a bin capacity of 1 car load of broken stone, and a mixing floor of concrete, 15 ft. x 15 ft. The maintenance outfit for the county includes two 2½ ton trucks, two 7 ft. gasoline motor-driven concrete mixers and four 400 gal. tank wagons for bituminous materials.



Road Patral Report, Gang Na. 1. Day Thur Date Sept 4th 1919

NAME	No.	Sections	Miles	Sq. Yds	Men	DISTRIBUTION OF TIME			
						Clean	Mix	Patch	Total Hr
Toledo-Napoleon	51	C.M	5.0	20	3		10½	7½	18
Detroit Ave	157	A	2.5	2	3			1½	1½
Glendale Ave	72	A.B.C	3.5	13	3			4½	4½
Michigan Ave	102	A.B	7.0	10	3			3	3
							10½	16½	27

No. Batches Mixed One Working of Station #1 Weather Fair

Will be on Road No. #158 Tomorrow and Road No #66 the day after. Following roads patrolled and needed no attention: Road No. #241

Mileage 26 No. Gal. Gas 5 No. Qts. Oil 1 Remarks:

Signed James R. Hall. Patrolman

☞NOTE—Cards must be mailed each night.

Postal Card Report Form.

District No. 1 is taken care of jointly by patrol gangs No. 1 and No. 2; Districts No. 2 and No. 3 are taken care of by patrol gang No. 2, and Districts No. 4 and No. 5 by patrol gang No. 1.

Each patrol gang takes the concrete mixer with it when it moves from one station to another. Each gang consists of truck driver, who acts as foreman, and five men, who mix the material, clean out the holes and fill them with bituminous concrete and tamp the same.

Gang No. 3 consists of three men, who act as a "flying squad" to repair damaged bridge floors, guard rails, washouts in bermes, etc. This gang also has a motor truck. In addition this gang paints guard rails, places and keeps in repair danger and warning signs, and attends to the thousand and one complaints that come into the surveyor's office.

The cost of operation has varied as regards patroling roads, but the big saving has been made in the general cost of maintaining them. The patching of holes, when small, alone has made the general cost per mile per year decrease considerably.

The method of patching is as follows:

No. 3 and No. 4 stone, ¼ to ¼ to ¾ in. in size, is mixed at the patrol station with bituminous cement in proportion of from 17 to 20 gal. of bitumen to 1 cu. yd. of stone. After thoroughly mixing, this is allowed to set for from 12 to 24 hours, according to weather conditions. The mixture is then loaded on the truck, and, as the roads are patrolled, each hole is cleaned out with wire brooms and then tamped full of the bituminous material, care being taken to see that the patch is left about ¼ in. higher than surrounding road. Traffic does the rest.

The following tables give some idea of the cost of patrol and maintenance:

COST OF ROAD PATROL.

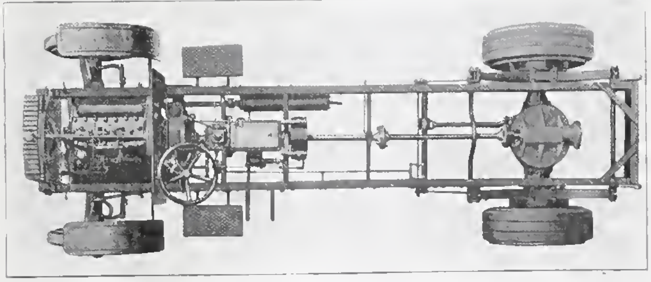
Including cost and maintenance of equipment.

	Road miles patroled.	Cost per mile.
1916	13.5	$ 57.10
1917	68.0	35.95
1918	404.9	33.67
GENERAL MAINTENANCE.		
1916	95.7	880.79
1917	183.1	725.44
1918	214.5	561.12

The above figures are all on macadam roads of various types. The illustration shows a typical report, one of which is made daily by the patrolman to the County Surveyor. By means of this it is possible to know each day just where the gang is and what it is doing, and to check at the end of the season the material bought and the yardage patched.

New 5-Ton Truck Has 10-Speed Transmission

A heavy duty motor truck having a ten speed transmission has been bought out by the G. A. Schacht Motor Truck Co., Cincinnati, O. The fundamental principle of the transmission is to enable the 5-ton truck to attain a high vehicle speed when conditions justify without dangerous engine speed.



Chassis of New Schacht 5-Ton Truck.

There are eight forward and two reverse speeds with a wide range of power reduction that will not only permit a high rate of vehicle speed but also provide tremendous pulling power on low and intermediate gears.

The Schacht 5-ton truck with ten speed transmission is stated to be capable of attaining a speed of 20 miles per hour at an engine speed of only 1,000 revolutions per minute. The main transmission has four speeds—first, second, third, and fourth or direct. The secondary transmission provides an extra reduction and can be used in connection with any one of the five regular speeds—so that there is a lower first, second, third, fourth and reverse. There are only two movements of the auxiliary gear shift lever—backward and forward.

The truck is motored by a new and heavier engine with a bore of 4½ in. by 6 in. stroke. This engine has been especially designed to stand the strain of increased speed and load carrying capacity which is expected from heavy duty engines of today. It is simple and accessible so that the average driver or repairman can keep it in good condition with a minimum of time and effort.

Lubrication is of the fall force pressure feed to all crank and cam shaft bearings through drilled crank shaft pistons and cylinders are lubricated by oil thrown from the lower ends of the connecting rods. The worm drive rear axle is exceptionally heavy and sturdy. It is made in the Schacht factory as is also 90 per cent of the entire truck, including frames, steering gears, transmissions, control sets, and radiators.

Problems Affecting Design and Construction of Highways*

By W. G. THOMPSON.

State Highway Engineer of New Jersey.

It has been said by a well-known railroad executive that the railroad of the future may find it more economical to tear up short line tracks and develop motor truck transportation in its place. Although the supplying of tonnage is the freight traffic manager's problem, it is also a problem which should engage the serious attention of the engineering department, from the viewpoint that every means should be employed to reduce the cost of supplying tonnage to the main lines, just as careful attention is given in location and construction, to reducing grades and curvature to the minimum. It is claimed that, considered as a unit, few branch lines pay expenses, but as gatherers of freight and passengers to increase density of main line traffic, they are sources of profit. As, however, traffic gathered by them is turned over to the main lines with a deficit attached, which has to be overcome during the main line movement before any profit is made, it might be a decided advantage if this traffic could be delivered to the trunk line by means of the motor truck or tractor, without this bill of expense attached.

Since it is a fact that it is now necessary to truck products of all kinds, and especially farm products to the short branch line, and load them into cars, a serious investigation of the matter may disclose that one handling might be obviated and considerable expense saved if the tracks were removed from many branch lines and the grade used for an improved motor road, which could be entered from every intersecting highway. Such an arrangement would mean increased facilities at main line points for freight handling, but with the present rapid improvement of country and interurban highways, it would relieve the railroads of the burden of maintaining freight stations, water systems, coaling stations, track and other structures, and the inevitable overhead expense during seasons when traffic is light.

It is inconceivable that trunk highways paralleling trunk lines of railroads will ever seriously affect the tonnage carried by the railroads, but it is quite conceivable that with the extensive building of hard, smooth, all-year highways, the tonnage of branch line roads will be very seriously affected, and in my opinion this problem should from now on engage the attention and induce careful investigation by the engineering departments of railroads, whose managers are looking to the future and the economical handling and transportation of freight.

There are at present, approximately 6,000,000 passenger motor cars in the United States. Conservative estimates place the passenger mileage of automobiles in the United States at 45,000,000,000 per annum. Commercial motor cars increased from 60,000 in 1912 to approximately 600,000 in 1918. The mileage for all kinds of commercial motor cars is now estimated at 5,000,000,000 ton miles per year. It is estimated there will be in use at the end of the next 10 years 20,000,000 passenger and 5,000,000 commercial motor cars. Surely the above figures should cause railroad officials more than casual concern and lead to consideration of the matter of short line hauls from the highway viewpoint.

Highway engineering today differs little from railway engineering. The same fundamental principles are involved in the original design of both, viz.: Alignment, grades, curves, drainage of subgrade, bridges, superelevation of curves, etc. There must also be traffic regulations and signals, danger signs, distance and direction markers, etc. Particular attention is being given to grades and curves, especially on the New Jersey state highway system, where, except in very hilly country, 5 per cent grades and 6° curves are the maximum.

The advent of the swiftly moving-motor vehicle soon demonstrated that the earth and macadam pavements were unsuitable and uneconomical for that class of traffic, therefore the most durable types such as concrete, stone block, asphalt and brick pavements are now being laid Light foundations and inadequate drainage are the most fruitful causes of pavement failure, as they are in track construction. Systems should be provided for thorough drainage of the subfoundation, such as lateral drains under the pavement, leading to longitudinal drains, the construction of storm sewers on a grade in long level sections; and the construction of side ditches and gutters. In the preparation of subfoundation, all areas of permanent saturation are removed and replaced with coarse sand or broken stone placed directly beneath the pavement. Experience is developing the fact that concrete provides the most durable and lasting foundation under heavy traffic. It is being used in rapidly increasing amount as a pavement and as a foundation for other types of pavement.

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*From an address before the New York Chapter of the American Association of Engineers.

On country and interurban highways, graded widths from gutter to gutter are not less than 30 ft. and the hard pavement not less than 18 ft., widening to 24 to 30 ft. where several roads converge, or when approaching large cities. All curves exceeding 3° are superelevated, as in railroad practice, in accordance with a formula devised for the purpose and based on a speed of 30 miles per hour, though some of our banked curves have been driven at 60 miles per hour, presumably because the driver liked the sensation of rounding a curve at high speed without the effort of resisting the overturning force.

Laws of most eastern states permit gross loads of from 24,000 to 30,000 lb. on trucks, therefore bridges are being designed for 20-ton loads, assuming 75 per cent of the load as being on the rear axle.

Rapid increase in use of motor vehicles makes pertinent the question as to whether we are building pavements sufficiently wide and foundations sufficiently heavy. The first is a matter of local finances; the second is one which can be determined only by experience and observation, extended over a period of years. On our most heavily traveled route, that between Newark and Trenton, we are laying a concrete pavement 8 in. thick at the sides and 10½ ins. at the center. On all other routes the pavement is being laid 6 in. at the sides and 8¾ in. at the center. It is believed these will suffice for 15 or 20 years.

A comprehensive system of marking the highways with danger, distance and direction markers is being installed to enable the motorist to travel from place to place with convenience and safety, if he will but observe the traffic regulations and ordinary courtesy to others.

Highway and highway transportation engineering offer a broad, promising field to young engineers in the future. There are objections to employment in public service, the principal one being uncertain tenure of office, due to changing political administrations, but it is within the power of the engineers of this country, by united and persistent effort, by educational propaganda, the exercise of tact, good judgment and constant adherence to the high ideals which actuate 99 per cent of our engineers to so mold public opinion that within a very few years the civil engineer may attain the social and economic status which are rightfully his, especially in the administration of public business and affairs. To most engineers, the idea of mixing or entering into politics is repugnant, but the present political system and the appointment and election of misfits and unfits will continue until the people of this great nation are educated to demand trained, experienced, practical men for the conduct of public affairs.

Federal Aid Road Projects.—Pennsylvania had first place in the number of statements approved during July, the amount of Federal aid allowances, and the estimated cost of roads to be constructed, while Nebraska turned in the greatest mileage. Seventeen projects in Pennsylvania approved will cost $4,607,028.41 for which the Federal aid is $1,968,997.40. Ohio with 12 projects came next to Pennsylvania in the number approved and in the estimated cost of the roads to be improved, and third in the amount of Federal aid. Oklahoma's two projects occupy third place for the month in the estimated cost of the roads and second in the amount of Federal aid allowance. This State leads the country in the size of a single project handled in July. It is estimated to cost $1,271,555 for which $600,000 Federal aid is allowed. In the record of approvals for the month of August Arkansas occupies first place in the estimated cost and mileage of projects and in respect to the largest project. Minnesota is first in the total number of projects approved, namely 11, and second in the amount of Federal aid allowances. Pennsylvania received the largest amount of Federal aid and her six approved projects come second in the estimated cost of the roads.

Engineers Resent 1916 Basis for 1919 Salaries

"Adverse criticism has been offered by individuals and organizations representing the engineering profession in the United States to the recommendations for the classification of employees in the Canadian civil service made by the accounting firm of Arthur Young & Co., of Chicago, Toronto and New York."

This we learn from the Engineering News-Record of Sept. 25, and as we continue reading the account of the report, we wonder that so mild a term as "adverse criticism" is the limit of quoted opinion. The News-Record takes up an analysis of the report made by a member of the Federal Government Section of the Engineering Council Committee on Classification and Compensation of Engineers as follows:

"The Canadian report is published in two parts. The first part, a volume of 82 pages, describes the principles and the methods underlying the classification, and the second, a volume of 678 pages, contains what is called the 'classification.'

"The Canadian report bases salaries, not upon living costs at the time the classification was made, but upon what would have been normal conditions for 1918 had the tendencies of the period prior to the war continued and had the war not occurred. Under the heading, 'The Principles and Policies Adopted as a Basis for the Recommended Schedules of Compensation,' in Part 1 of the Canadian classification, is the following:

"5. That the salaries proposed should not be based on the depreciated value of the dollar of the present time as measured by the abnormally high costs of the necessities of life that have developed as a result of the war. Conditions are now not stable. Economic conditions the world over are in an unsettled and uncertain state, and to found a salary revision on what may prove to be temporary conditions might involve the necessity of a downward revision when conditions return toward the normal. On the strength of these considerations it was decided to base the general level of the salary schedules on what would have been normal conditions for 1918 had the tendencies of the period prior to the war continued and had the war not occurred."

This curious attempt to find a basis for present day prices or charges by a projection of trend curves from the period prior to the World upheaval is observable in other places than the Young report. Certain valuation engineers are doing exactly the same thing in determining unit prices for their appraisals. Presumably those who follow this course base their action upon a belief that history is about to turn aside into the channel it was following 6 years ago, but frankly we can see no justification whatever for such a belief. That present conditions are unstable none can deny; but that there will be a reversion to substantially the old order seems to us to be a most improbable outcome. In fact any attempt at close prediction of these matters requires an amazing temerity.

In the meantime the salaried man is living in 1919, under 1919 conditions—not under the conditions of 1920 or 1921, whatever those shall be—but on the chance that there may be reductions at an indefinite future time, the Young report asks that salaries as of 1914 be made to bear the burden of 50 per cent to 100 per cent increases in living costs, instigated by the recommendation of a bonus of indefinite amount. It does not require years to bring the sufferings of penury upon a family, or to dissipate the savings of half a lifetime of industry and frugality. The carrying out of the recommendation of the Young report must inevitably add to the social and economic unrest. Among those injured by it there will be the feeling that the world is selfishly against them, and will take what it can, ergo: "We will take what we can." Such thoughts breed Bolshevism in the hope of a remedy, or lawlessness in the despair of one.

But in the statement that "fairness to the employee requires that the compensation should permit him to maintain a standard of living such as to make for the good of society and posterity," the report lays claim to justice, and quotes the report of the Bureau of Labor Statistics for the District of Columbia to the effect that "this would indicate that a minimum-of-comfort budget, according to the practices and standards of domestic economy prevailing in Washington in 1916, must be about $1200. Since 1916 the cost of the necessities of decent living, weighed according to importance in the family budget, has advanced approximately 50 per cent.

This indicates that an identical standard of decency cannot be purchased for less than $1800 today."

Commenting upon this report, an engineer said:

"No data are available for comparing living costs in Canada and here. Presumably they are somewhat less there. However this may be, in the Canadian classification 700 classes and subclasses, or 35 per cent, have a minimum salary rating of $1200 or less, and 500, or over 25 per cent have $1000 or less. Even if we assume that a reasonable living wage in Canada in 1916 was $1000, as compared with $1200 in the District of Columbia, the rise in price levels would make $1540 the living wage in Canada in these years. Of the 1970 classes and subclasses, nearly 1,100, or 56 per cent, have a minimum salary rating of less than $1540 per year—that is, in 1918 and 1919 would not have paid a living wage to a family of five. While undoubtedly many of the lowest grades carry subsistence or other perquisites in addition to the salary, such a provision is not likely to affect many grades above $1000, or materially to change the proportion of classes which, all compensations included, receive less than $1540 per annum."

Arthur S Tuttle, chairman of Engineering Council's Committee on Classification and Compensation of Engineers, in a recent letter to Secretary Flinn finds that the Canadian report "is open to serious criticism on the ground that it fails to group engineering service along orderly lines, that it provides too narrow limits for promotions within a grade, and that the compensation proposed for all grades is inadequate for the service rendered."

"The report states that the compensation proposed are intended for 'normal times' and that, pending restoration of such time, the rates recommended should be 'supplemented by a bonus,' but no information appears as to the magnitude of the bonus.

"From my study of the report it would appear that the groups and ranges of compensation, tabulated as far as practicable under the classification tentatively proposed by Engineering Council's Committee are about as indicated in the table:"

TABULATION OF TITLES AND SALARIES FOR ENGINEERS IN CANADIAN CIVIL SERVICE REPORT UNDER CLASSIFICATION PROPOSED BY COMMITTEE OF ENGINEERING COUNCIL.

Tentative Classification of Positions in State and Municipal Service Proposed by Engineering Council's Committee on State and Municipal Service.	*	Salary Range Proposed for Canadian Service. Usual Min.	Usual Max.	Extreme Min.	Extreme Max.	Qualifications Proposed for Canadian Service.
Consulting engineer	1	$6,000	.....	.....	.....	Professional Engr. 12 yrs.' exper. (7 in charge)
Chief engineer (major work) ..	5	6,000	.....	$4,800	.....	Professional Engr. 7-12 yrs.' exper. (3 to 7 in charge)
Chief engineer (minor work) ..	7	3,900	$4,800	3,600	$6,000	Professional Engr. 7-12 yrs.' exper. (3 to 7 in charge)
Chief engineer—deputy	8	3,900	4,800	3,600	5,700	Professional Engr. 7-12 yrs.' exper. (3 to 7 in charge)
Engineer	37	3,300	4,020	3,000	4,500	Professional Engr. 5-10 yrs.' exper. (2 to 5 in charge)
Senior assistant engineer	40	2,640	3,000	2,400	3,480	Professional Engr. 3 years' exper. (2 to 3 in charge)
Assistant engineer	23	2,100	2,580	2,040	3,120	Professional Engr. 3 yrs.' experience
Junior assistant ..	15	1,680	2,040	1,680	2,160	Professional Engr. 2 yrs.' experience
Senior draftsman..	..	Included in professional service				
Draftsman	8	1,260	1,560	.....	.....	3 years' experience
Junior draftsman..	4	900	1,200	.....	.....	2 years' experience
Chief instrument man	..	Included in professional service				
Instrument man ..	5	1,260	1,560	.....	.....	3 years' experience
Rodman	4	900	1,200	.....	.....	2 years' experience

*No. of titles provided in proposed Canadian classification.

Big Federal Aid Road Jobs.—Among the special features of the recent Federal aid road record as kept by the United States Department of Agriculture, are three road projects to cost over $1,000,000, one of them over $2,000,000. On a Massachusetts project, a short concrete road, the estimated cost is at the rate of $127,864 a mile. This is the highest average cost per mile so far shown in any Federal aid road. A bituminous brick or concrete road in Ohio will average $67,716 a mile.

Kentucky Practice in Construction of Water Bound Macadam*

By M. D. ROSS,

Division Engineer, Department of Public Roads, Newport, Ky.

The well known characteristics of a properly constructed water-bound macadam road are: A well drained, carefully shaped and thoroughly compacted subgrade; properly shaped shoulders and ditches to insure the removal of surface water, and a layer of thoroughly compacted, properly bonded crushed stone, the surface of which has been well keyed together by rolling so that it represents a compact mass of stone of sufficient size to bear the loads that will pass over it without crushing, and in which the stones are mechanically locked together by rolling and held in place by means of dust from the crushed stone which has been worked into the crevices between the stone by means of water and rolling.

General Considerations Regarding Grade and Drainage.—As a properly constructed water-bound macadam road is a costly investment, careful consideration should be taken to make the important features permanent. The fixing of the maximum grade will be governed by at least two conditions: one the amount of the load that can be hauled over the grade, and the other the cost of maintenance. It has been conclusively demonstrated that grades should not exceed 5 per cent, on the other hand when possible, there should be enough grade to secure ample drainage.

Great care should be taken to see that all drainage is such as will not cause failure of the road. If the subgrade becomes water soaked it should be drained by means of tile subdrain. The side ditches should be ample to carry the heaviest flow of water and a wide shallow ditch is preferable to a deep narrow one; they are much easier to construct, cheaper to maintain and are not dangerous to traffic. All ditches should drain to a natural drainage point, through a culvert and away from the road.

Width of Macadam.—A well constructed macadam road will have a width of at least 26 ft. from center to center of ditch in cuts, and at least 20 ft. from outside to outside of shoulders on fills, figuring 9 to 14 ft. of metal. At this point we will consider carefully the width of metal that should be used. This question is a much discussed one, some states have adopted 14 ft. as the least width of stone surface, some 12 ft. and some 9 ft.; the width required depends altogether upon the amount of travel. For a good many of our roads in Kentucky 9 ft. of metal with a graded width of 20 to 26 ft. is ample. Of course, a 9 ft. metal road will not allow two vehicles to pass on the stone surface, but there are sections in some counties where it is comparatively seldom that two heavily loaded wagons have to pass, and where they do the shoulders offer a surface harder and firmer than the usual country road. This should be the minimum width and is only recommended where the heavy traffic is mostly in one direction. On the other hand, roads that are important and have considerable traffic in both directions, should never have less than 14 ft. of metal. This will allow two vehicles to pass each other safely, and if suitable earth shoulders are built on each side automobiles will have no trouble passing. If the stone is less than 14 ft. wide, there is a likelihood that the edges of the macadam will be sheared off by the wheels. The Kentucky Department of Public Roads has figured that any width less than 14 ft. is waste of money and of little value, unless the surface is reduced to single track of 9 ft.

Construction Equipment.—In considering the construction of a waterbound macadam road the section used will be a 14 ft. metal surface. The equipment used in addition to picks, shovels and ordinary implements are a heavy construction plow for loosening the earth, wheel scrapers for filling the low places and wagons for moving the earth any distance. Bottom dump or spreading wagons will save money, as they are used to advantage in spreading the stone, and often eliminating handling the stone twice. A scraping grader or road machine will be especially needed for shaping the subgrade, ditches, etc. A steam roller of at least 10-ton size is indispensable in the construction of a modern road, both for preparing the subgrade and rolling the broken stone. Water plays a large part in making the stone cement together so a watering cart or sprinkler of about 500-gal. capacity should be secured. The tires on it should be extremely wide and the sprinkling arrangement should be such that the water will be sprayed on to the crushed stone in a gentle, full and evenly distributed stream.

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*From a paper presented at the 1919 Road School at the University of Kentucky.

Unless it is cheaper to have the stone shipped from some regular quarry, or unless there is no suitable local stone available, a portable crushing outfit should be provided, consisting of a boiler, an engine, the crusher, and portable bins with a rotary screen and elevator to receive the stone from the crusher and to lift it into the screen from whence the different sizes are discharged into their respective bins. The crusher should be so arranged that the stone can be dumped on a platform built around the mouth of the crusher, so that the stone can be fed into the crusher without further lifting, and the bins should be so arranged that the crushed stone may be loaded into the wagons by gravity. The plant should be located as centrally as possible to the work, if possible the crushed stone should not be hauled over a mile, yet at the same time it must be convenient to water, as a great amount is needed for the boiler. The size of the crusher should be such that the output will be from 75 to 100 cu. yd. daily, as the roller can easily roll this much each day.

Preparation of Subgrade.—Considering all fills and cuts having been made, and the subgrade roughly prepared, then all spongy materials, vegetable matter, roots, stumps, etc., should be carefully removed from the roadway; nothing should be used but sound earth. The cross-section of the surface, slope, etc., is as follows:

In cuts the side slopes should be at least 1 to 1 and for a 14-ft. metal surface the width between center of ditches should be 26 ft., which includes 14 ft. of metal, 3 ft. for each shoulder and 3 ft. to the center of each ditch.

The slope of metal surface should be ½ to ¾ in. vertical to 1 ft. horizontal, the 3 ft. from the edge of shoulder to center of ditch should have a fall of 4 in. to 1 ft., a total for 3 ft. will be 1 ft. depth of ditch. The only difference in section for fills is the 3 ft. slope from shoulder will run from 3 to 1 slope into 1½ to 1 slope, all fills will naturally slope 1½ to 1, making the total width from outside to outside edge of shoulder 20 ft.

In preparing the subgrade for the broken stone if trench excavation is adopted most of the dirt to be moved in making this trench can be plowed and thrown out with an ordinary road grader at small expense. The width of the trench should be the same as that of the macadam, or 14 ft. and the depth the thickness of the bottom course of macadam.

Usually in constructing the subgrade with proper use of the road grader having the blade at such an angle as to cut half the required width of surface to be metaled, sufficient material is left on the side to form the shoulder for the macadam; this subgrade can be properly crowned and brought to the proper cross section by adjusting the blade to the right angle.

After the subgrade is shaped to the approximate cross section it should be rolled thoroughly until it is hard, firm and smooth. If soft places are found or depressions develop during the rolling, more good material should be put on. Remember that the subgrade should be shaped and rolled properly as bumps and hollows left in the subgrade will show up in each succeeding course. After the subgrade is made it is very important to have drains cut through the shoulders (at intervals of 50 ft.) to the side ditches. This may save many days work and will keep the subgrade dry when otherwise it would be flooded at every rain.

After the roadway has been graded with reasonable care, the surface upon which the broken stone is to be placed, must be hard, smooth, and carefully crowned to the same section as the finished roadway will assume.

Bottom Course of Stone.—After the subgrade has been prepared for a few hundred feet, the spreading of the first course of stone should be commenced. This ordinarily consists of stone broken to sizes of from ¾ in. to 3½ in., and should never be larger than 3½ in. for our ordinary local limestone. In macadam construction where harder rock exists the maximum dimension is limited to 3 in. This is because the soft stone will often crush under the roller to a greater extent than the harder. Any stone larger than 3½ in. in any dimension should be broken with a napping hammer. Stone for the first course need not be of especial hardness or toughness. Ordinary limestone of any kind may be used. The thickness of the course varies with the local conditions. For the average waterbound macadam road in Kentucky a thickness of 6 in. loose will be the average, and should be mostly used. A course of 6 in. can be thoroughly rolled with a 10 or 12-ton road roller. Any thickness over this is not advised as it cannot be consolidated properly.

This course should consist of a single layer of stone spread uniformly on the subgrade. The metal should be dumped on dumping boards, unless spreading wagons or trucks of approved type are used. In spreading stone care should be taken to secure the required thickness and no more; the tendency seems always to use an excess amount. One way to prevent this excess is the use of wooden blocks about 6 in. square with a height equal to the required thickness of the loose layer. These blocks should be used on each side and the center, and the stone should then be leveled carefully to the top of these blocks. It is very important to have a good man in charge of the spreading as proper and economical spreading in many cases makes a saving of hundreds of yards of material per mile.

After 100 ft. or more of the first course of stone is spread and carefully shaped the rolling should commence. In rolling, there is one thing to remember: always roll the sides first, and when both sides are firm work gradually towards the center. This insures a uniform compacting of the stone. Finally roll until the whole surface has been rolled with the rear wheels, then there is no danger of spreading the stone. The roller should run as nearly parallel to the center line of the roadway as possible. If this rule is not followed the roller will mash the stone out flat and spoil the crown. There is no set rule as to how much the stone should be rolled. Experience will soon teach how much to roll any particular kind of stone. Granite and other hard stone require more rolling than do limestones, and in general the harder the stone the more rolling is required. In testing the stone to see if it has been thoroughly rolled one should be able to walk on it without causing much movement of the stone except just under the feet.

All irregularities and depressions which may develop should be corrected with additional metal as the rolling progresses and the whole surface should be thoroughly compacted after such additions and corrections so that it is firm and true to the grades and cross-sections. Screenings of sizes ranging from ¾ in. to dust should be spread with shovels from piles along the roadside and in no case should the screenings be dumped on the surface. Screenings should be spread in thin layers and each layer rolled dry, this process being continued until the screenings are slightly below the surface of the rolled metal. Excess screenings should be scattered with brooms.

Upper Course.—In deciding upon the size of the pieces of stone to be used for the upper layer of a waterbound macadam road, the things to be taken into consideration are the quality of stone available for use, the amount of traffic, and the weight and character of the loads which will pass over the surface. With a road surface carrying traffic made up of a great many heavily loaded horse-drawn vehicles, together with a large number of motor-driven vehicles, if the pieces of stone in the surface of the road are so small that the wheels passing over them crush them it is inevitable that the rapid wear will result and the road will be destroyed quickly. On the other hand if the surface of the road is made of large pieces of stone the traffic will not crush them nor even wear them with sufficient rapidity to supply fine material to fill the cracks between the stone and keep the voids filled, notwithstanding the action of the elements and traffic. In such a case the road will become rough and uneven, the surface being made up of rounded stones which project slightly and make it disagreeable to traffic. Considering this, it has been found with the limestone available in Kentucky, the size ranging from 1½ in. to 3½ in. is most satisfactory. When stone of this size is used it is, of course, desirable to have the surface layer made up of fairly uniform pieces and should be screened as closely as possible to these sizes.

The upper course should be spread with blocks to a depth of 4 in., loose measurement, as after careful consideration of the quality of our local stone and traffic conditions this thickness has been found most satisfactory. This course must be spread the same width, with the same care as the first course and rolled in the same manner. In commencing to roll the second course the outside of the wheel of the roller should rest half on the shoulder and half on the stone so as to keep a uniform cross slope to both, and to pack the shoulder in order to keep the stone from spreading. Whenever possible the shoulder should be rolled for a distance of at least 2 ft.

from the stone, at this period of the road's progress. Roll as before from the sides to the center until the stone is firmly in place so that a gentle kick will scarcely dislodge a stone and the surface is firm and even. Any depressions or bumps in the stone should be level or filled with additional stone (of same size as the rest of the course) and all wheel tracks smoothed out and the roller run over such places until the surface is hard and smooth.

The Binder Course.—After the second course has been consolidated to the proper cross-section, the third or binder course should consist of stone screenings varying from ¾ in. in size to dust. Limestone screenings are generally used in this construction as the same material comprises the other courses, although sand and gravel has been used for binder for some rock with good results. The screenings should be spread from wagons or from piles alongside the road. They should never be dumped directly on a stone surface. In applying screenings a quick jerky motion is necessary, so that a shovelfull goes over a large area. They should be spread in thin layers, and each layer rolled dry, this process being continued until the screenings are flush with and not above the top of the rolled metal. If screenings are spread before the stone has been thoroughly rolled they only serve to separate the larger stone. The resulting surface is made up of individual stones set in pockets of screenings and is not as durable as one made of stone firmly locked together by rolling before any screenings are spread. All excess screenings should be scattered with brooms.

After spreading the screenings the road should be thoroughly sprinkled with water from the sprinkler to wash the screenings into the voids in the stone. Water thoroughly until it bubbles and flushes or rises to the surface as this shows that the voids in the stone have been properly filled. Follow the sprinkler with the roller and roll well, sprinkle and roll until the roller following close behind the sprinkler has a wave of water continualy going before the wheels. This flushing may cause the dust to settle and bare spots to show up; cover these with more screenings, wet and roll until the surface is firm and hard and uniformly covered with a thin coat of dust. Don't make the mistake of using too much screenings. If more than just enough to fill the voids and cover surface is used, it will cause ruts under traffic and water standing in them will soften the surface and the result will be destruction of the road. After a section of road has been flushed and finished as above described, it should be left to set and dry out and then be watered and rolled so as to make a thorough bonded surface. The surface when completed should present a granular surface with no excess of screenings and should be so hard that a piece of rock will crush beneath the roller, before penetrating the surface.

When a section of road is finished the road grader should be used to go over the shoulders and all surplus dirt removed until the road has as nearly as possible the cross section that the finished road should assume. By setting the blade to the proper slope, this can be readily done with little expense When the finished macadam road (with 6 in. of loose metal for first course and 4 in. for second course) is properly rolled and bonded, it results in a compact mass of metal approximately 7 in. thick. It has been figured that 7 in. compacted metal built on a proper sub-grade is sufficient to take care of the average traffic. The method of constructing a macadam road as outlined above, will be found in the General Specifications gotten out by the Kentucky Department of Public Roads, and if followed closely the best results will be obtained.

Michigan State Roads Under Contract.—During the past two years the State Highway Department of Michigan has approved contracts for the construction of 706 miles of state trunk line, Federal aid and Covert act roads, representing a total expenditure of $8,378,509. Since July 3, 1919, the department has authorized the construction of 181 miles of state trunk line road at a cost of $2,207,505.87. The total awarded under the Covert act since Aug. 2, 1917, is 324.5 miles at cost of $3,317,710.14, while the Federal aid contracts authorized since Sept. 29, 1917, call for the construction of 201 miles at a cost of $2,853,293.

$1,000,000 Road Contract.—Dallas County, Texas, will soon call for bids on a road contract calling for an expenditure of about $1,000,000.

Reflections on Engineering and Education*

By JOHN F. HAYFORD.

Engineering is the foundation of our present civilization. Please note that I have not said that engineering is our present civilization. Civilization is the whole structure, or perhaps I should say it is the superstructure. All of those things, ideas, ideals, which men think of as civilization, are in the superstructure which could not have been built so large or so well without the foundation, engineering. The superstructure, civilization, would fall if it were not for the solid foundation, engineering,—applied science.

The important point to keep in mind is that without the foundation, engineering, man does not have the time or energy to develop and maintain our present type of civilization. Without the engineering he cannot have the civilization. With it he has the possibility of becoming civilized, and history shows that he ordinarily makes much progress along that line.

The engineer who knows, and feels, that engineering is the foundation which carries the superstructure, our present civilization, which is something higher and better than the foundation, is naturally interested in that superstructure. He is keen to adapt his foundation to the superstructure. Naturally he is keen to see the human relations of his work and that of his profession. To him engineering is not mere technique.

Men, Service, Engineers.—Our slogan for colleges of engineering should be, let us educate men for service as engineers.

If we adopt this slogan with the proper emphasis on the three words, men, service, engineers, we are apt to remember that each man is an organism, not a machine, that he continues to grow and change long after graduation, that we can not hope to stock him in college with all the ideas and skill he will have later, that our function in college is to help vitalize the organism, to invigorate its growth, to start it in adapting itself to its future environment. We will think less perhaps of the possible condition of that organism during the first five years after it leaves the commencement stage, and much more of the way it will be functioning in the whole period of 40 years of service.

Specialization and General Education.—Which should receive the main emphasis, specialization or general education? The answer is, I believe, both, alternately. The most effective specialist is one who has the power and the ability to concentrate his mental pressure on so narrow a line that it is a cutting edge, who does so concentrate, and who at the same time keeps so broad a bearing on the world that his cutting edge is properly guided. The specialist who renders greatest service is one motivated permanently by a broad vision while his attention and power is concentrated on specific tasks for which he has made himself the superior of others. He needs a broad vision to motivate him and guide him to the service most worth while. The man who is broadly cultured, and nothing more, loses his cutting edge, loses his power to concentrate, fails to have the power to do the specific tasks which are parts of his service.

Intelligence Tests and Engineering Students.—I am convinced that intelligence tests have immediate value, even now, when we know so little about them. I feel certain that they will become much more valuable when they are better understood. This statement is made in order that I may be understood when I raise a question on one point in regard to such tests as applied to students of engineering.

It is strongly advocated that certain objective tests, which seem to me to be essentially vocational tests, should be used on engineering students. We are probably justified in being skeptical on this point. Engineering is not a narrow vocation and immediate success is not the important thing. An engineer, it is true, like all men, carries a routine load which may be specified in advance in some cases. But after all the valuable part in an engineer's service arises from his ability to see and solve new problems, to improve design, to meet the emergencies of operation, to put better methods of procedure in the place of the usual methods, to see the things that are not where he looks and which may be in the future only. The engineer's greatest service is based largely on his ability to see the things that are not obvious, to see the possible advances that are but obscurely indicated, to see in the blue-print and the description that which is a possible future fact worth while. The engineer who is of great service to the world deals, as a rule, with a great variety of things which may cover a large part of the whole range of science, including those undeveloped sciences which contain the laws of the reactions which occur in the contact of man with man, as individuals or in groups.

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*From the presidential address before the Society for the Promotion of Engineering Education.

It seems to me that any candid study of many engineers who have rendered great service to the world will show that they exhibit great variety in their general characteristics. Among the engineers who have rendered great service are men of the artistic temperament, men with great ability at the finger's ends and men with but little manual skill, men who have succeeded by direct attacks in person on the technical problems that came before them with little attention on the human elements in life and men who have worked almost entirely through other brains than their own, being great executives in the engineering field. There is still abundant opportunity in engineering for all of these types.

The engineers that we should aspire to educate have so broad a field, so great a variety of opportunity, such large powers of future expansion beyond their size while in college, and expansion in so many directions, that we should be skeptical of vocational tests or of objective tests of that type for them.

Please do not misunderstand. It is certain that there should be, and probably will be, much experimenting in the next few years in connection with various tests applied to students of engineering. It is only on one point in connection with the proposed tests that I have expressed skepticism. I believe that an engineer needs intelligence and must use it,—but not simply a particular kind of mechanical mathematical intelligence. Hence I believe that the future tests should aim to discover and measure intelligence,—rather than a particular brand of intelligence.

Lack of Vocational Training Greatest Defect of Educational System.—There is need of much clear recognition of the fact that the greatest defect in our educational system at present is the lack of vocational training. Trade-schools are needed,—trade-schools which are frankly and definitely devoted to training artisans of all grades, including the highest types, as for example, skilled draftsmen. The draftsman bears the same relation to an engineer that the trained nurse or the interne in a hospital bears to the surgeon. The trained nurse renders valuable service in that capacity for life. The surgeon's success is based on her skill and fidelity. The interne is for a time in much the same relation to the surgeon as the trained nurse. But he is developing up through that experience to become a surgeon. So also a good road to the engineer's position runs by way of temporary service at the drafting-table.

If we had well-developed, frank trade-schools, many of the best men for the routine work which is the basis of engineering would be developed in those schools, and probably the draftsmen would largely be developed there. As a result we would have better workmen, better foremen, better operators, better draftsmen. As artisans of higher grade were developed in such a well-planned system of trade-schools we would be face to face in time with even greater difficulties than now in drawing a clear, definite line to separate the highest grade of artisans from the engineers. The engineers would find the emphasis in the lines in which they served going more and more to the creative side, the improvement side. The engineer's education would in time respond still more than at present to that kind of a demand on his ability.

The establishment and frank development to their highest capabilities of trade schools for artisans would give the graduates of such schools better preparation for their future service in a shorter time than they can now get it, either by experience merely or by studying to be artisans in a college of engineering.

Permeating many of our educational problems in this society are obscurities that arise from the fact that the essential difference between the high-grade artisan and the engineer is not clearly seen and the corresponding action taken. In military life everywhere a clear distinction is seen between the private, or non-commissioned officer, and the officer. That distinction clearly seen and acted upon is effective both in contributing to the efficiency of the organization and in developing the individual in it.

As in military life, the exceptional men frequently pass from one of these classes to the one above, from the noncommissioned to the officer class, so we should expect even though we had the ideal educational system, that exceptional men, trained as artisans would rise to the professional class.

Application of War Time Experience to Times of Peace.—I desire to raise and emphasize three broad questions arising out of the war experience. First, In the next ten years in our colleges of engineering will the successful motivation of our students be a military motivation, or a motivation in some other line? Second, Is it possible to get a real speeding up in the education of engineers in time of peace that shall correspond to that which was secured in the training of men for specific tasks in war time? Third, Is it our patriotic duty to train all, or large numbers, of our students to be military engineers? Or will we serve the nation still better if we educate them thoroughly as engineers and let them get at college or in camps whatever small amount of the essentials of strictly military knowledge experience may show each man should have,—but get it without interruption of their engineering education or distortion of that education.

Our young men under the spell of the unanimous determination to fight the Hun had an extremely strong military motivation. Did that motivation show a sudden lapse when the armistice was signed? Are the young men now in college showing the intense motivation toward military occupations that they did in 1917 and 1918? Should they show such a motivation now if they see things rightly? Is the task now imminent before us in the world essentially military,—or essentially a peace task? Consider the mental attitude of the boys now in college. Do they take to military training with avidity? Is not the military motivation for engineering students largely a thing of the past? As motivation is extremely important to our success as educators should we develop a new motivation in the place of the lost military motivation,—or take advantage of whatever motivation now exists in nascent state in our young men? A frank and full consideration of these queries will also furnish a true answer to that first question, which was "In the next ten years, in our colleges of engineering, will the successful motivation of our students be a military motivation, or a motivation in some other line?"

Next, Is it possible to get a real speeding up in the education of engineers in time of peace that shall correspond to that which was secured in the training of men for specific tasks in war time? Education is essentially a slower process than training. The more specific and narrow the task for which a man is to be training the more quickly he may be trained. Each piece of war time training was purposely and rightly made as specific as possible. An engineer needs an education which shall fit him for a large variety of somewhat vague tasks. To train a man to do things at once thus and so,—is an undertaking which lends itself readily to a speeding up. But it is a much harder task and one which is essentially much slower, to educate a man so that he will think. This is what we must do for our future engineers. Let us keep these things in mind, and apply the necessary correction factors, whenever it is tacitly assumed, or openly asserted, that the war experience in training for specific tasks with great speed shows that we may educate engineers in a much shorter time than we have in the past. Of course we can do better than we have in the past—but education cannot be speeded up to the same limit as special training.

In discussions as to possible changes in our educational system one tacit assumption frequently made is that it is our patriotic duty to put much of a military complexion into our training of engineers, that it is our patriotic duty to pay considerable attention to military engineering in the training of engineering students. I challenge that assumption. I believe it to be clearly a mistake and have indicated my belief in the third question,—"Is it our patriotic duty to train all, or large numbers of our students to be military engineers? Or will we serve the nation still better if we educate them thoroughly as engineers and let them get at college or in camps whatever small amount of the essentials of strictly military knowledge experience may show each man should have,—but get it without interruption or distortion of their engineering education."

In the war just ended the original engineer arm of the United States Army was increased to 131.5 times its pre-war strength. Eleven per cent. of our total force was made up of engineer troops. On the face of it this means that as a patriotic duty we should train an extremely large number of military engineers. But is that the correct conclusion? The expansion was made by taking men educated for engineering, and with experience as engineers in practice, for officers, and using for the rank and file in engineering troops, artisans in engineering lines with a peace time occupation similar to that which was to be theirs in war. It was found to be both an easy and a short task to give them, the officers and the men, the essentials of strictly military knowledge. They did their war work well and promptly. In general throughout this war, in so far as the United States was concerned, the greatest shortage was never in trained officers and men. It was in transportation and materials. The higher the development of engineering in peace time in a given nation the more quickly these shortages of transportation and of materials can be met. Our engineers in war faced the same problems as they had been accustomed to in times of peace. If we train our future engineers to solve the problems of peace more thoroughly we will be doing much more to increase their effectiveness in war than by giving them in advance a little smattering of so-called military engineering. The great principles of military strategy remain the same throughout all ages. But the tools and the tactical methods of war change each generation with the advance of applied science and are conditioned on the state of that advance. We as engineering educators shall contribute more to the national welfare by raising the state of the art, engineering, than we can in any other way.

In the process of doing our best for engineering, by improving engineering education while we hold fast to that which is excellent in our present methods, we should of course welcome any enrichment of courses and improvement of methods which may come from our military experience or our military arms.

Our greatest service to the nation will be to do our best to make this nation foremost in engineering in time of peace,—and therefore foremost in military engineering in time of war when, and if, war shall come. Our service will be of the highest type if there is ever before us the realization that engineering is the foundation of our civilization,—if we realize that we make a better superstructure possible when we build the foundation better,—if we realize that our part is ever to foster a better, broader, more thorough engineering education than has ever yet been given.

$1,265,000,000 of Highway Bond Issues Proposed or Authorized in 1919

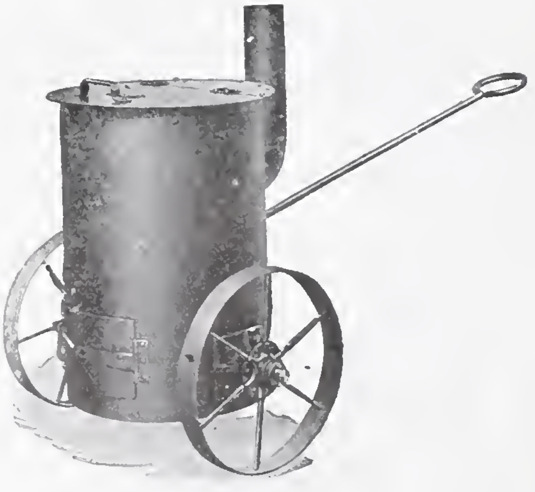
Highway bond issues aggregating $493,865,490 were authorized between Jan. 1 and Sept. 15, 1919, by states, counties and road districts, according to statistics compiled by the Portland Cement Association. In addition bond issues totaling $772,943,500 were proposed.

The following table shows the state and county issues:

	Proposed.	Authorized.
Alabama—		
State	$25,000,000	....
County	5,000,000	....
Arizona—		
County	10,750,000	$ 4,400,000
Arkansas—		
State	15,000,000	....
County	100,000	2,000,000
California—		
State	....	40,000,000
County	5,585,000	17,535,000
Colorado—		
State	5,000,000	....
Delaware—		
County	....	500,000
Florida—		
State	10,000,000	....
County	....	1,065,000
Georgia—		
State	40,000,000	....
County	7,835,000	14,245,000
Idaho—		
State	2,000,000	....
County	3,405,000	6,773,000
Illinois—		
State	....	60,000,000
County	11,398,000	2,615,845
Iowa—		
County	4,500,000	18,475,000
Kansas—		
State	60,000,000	....
County	....	50,000
Kentucky—		
County	....	1,050,000
Louisiana—		
Parish	3,130,000	3,100,000
Maine—		
State	....	8,000,000
Michigan—		
State	....	50,000,000
County	1,800,000	2,100,000
Minnesota—		
State	100,000,000	....
County	4,182,500	12,500,000
Mississippi—		
State	20,000,000	....
County	4,080,000	3,815,000
Missouri—		
State	60,000,000	....
County, District or Township	21,435,000	11,378,000
Montana—		
State	15,000,000	....
County	160,000	6,283,000
Nebraska—		
County	....	3,000,000
Nevada—		
State	....	1,000,000
County	600,000	200,000
New Jersey—		
County	605,000	....
New Mexico—		
State	2,000,000	....
County	200,000	....
North Carolina—		
State	25,000,000	....
County or Township	5,505,000	13,109,635
Oklahoma—		
County	7,860,000	1,158,000
Oregon—		
State	....	12,500,000
County	....	7,196,704
Pennsylvania—		
State	....	50,000,000
County	8,225,000	16,665,500
Rhode Island—		
State	1,000,000	....
South Carolina—		
County	1,560,000	8,025,000
South Dakota—		
County	13,000,000	....
Tennessee—		
County	5,000,000	6,685,000
Texas—		
State	75,000,000	....
County, Precinct or District	22,790,000	73,532,000
Utah—		
State	....	4,000,000
County	1,306,000	1,500,000
Washington—		
State	30,000,000	....
County	500,000	7,875,000
West Virginia—		
State	50,000,000	....
County or District	13,972,000	5,213,200
Wisconsin—		
State	50,000,000	....
County	24,000,000	12,920,000
Wyoming—		
State	....	2,800,000

Small Portable Bituminous Material Heater for Patrolmen

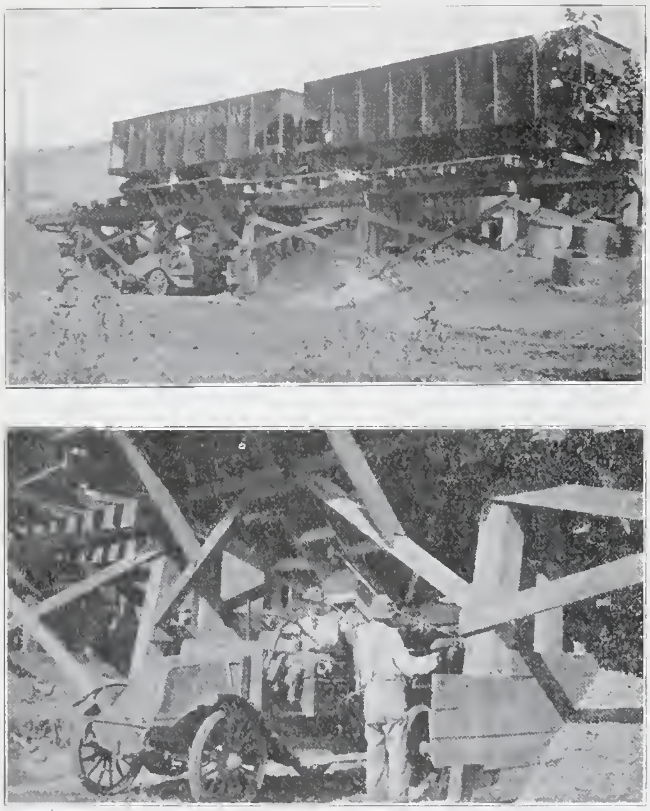
A small portable tar and asphalt heater designed especially for use in connection with road patrol systems has been placed on the market by Littleford Bros., 450 E. Pearl St., Cincinnati, O. With this outfit the patrolman or operator, covering a limited mileage, is in a position to make patches immediately after the road shows signs of wear. The heater is durably constructed of sheet steel, and the design is such as to make it easily handled by one man. The fire box is fitted with cast iron grate and hinged fire door. The welded kettle rests entirely within the fire box and is removable; it has a capacity of 8 gal.



Littleford Patrol Heater.

Trestle and Tipple for Loading Broken Stone into Trucks

The accompanying cuts, showing the method of loading trucks from railroad cars, used by Wilmurt A. Bennett, engineer and contractor, Rocky Mount, Va., on a macadam job at Rocky Mount, Va., illustrate how it is sometimes possible for a contractor to make use of local conditions greatly to his advantage. The trestle was built on the site of an old turn table which had been removed, leaving a round hole in the ground about 60 ft. in diameter and 5 ft. deep with a spur track ending at the circumference. This hole was graded out about 2 ft. deeper and one side cut away to give access to the center. The track was then raised for a distance of about 100 ft. back and extended across the excavation with a 2 per cent grade to facilitate moving cars by hand.



Arrangement for Loading Trucks From Railroad Cars.

Two cars are spotted at a time, and after the first is unloaded through the tipple it is released and rolled down the track so that the other car may be eased down into position. One man is required in the car and one on the ground, and these two men handle the material at an average rate of 150 cu. yd. per day, giving a cost of 4 ct. per cubic yard. The cost of the trestle was $635 and it will handle about 6500 cu. yd. of material, making the total cost of handling from cars to trucks 13.8 ct. per yard. A few cars dumped on the ground and loaded into the trucks by hand gave a cost of over 46 ct. for handling, to say nothing of the additional cost of truck time.

The hauling is done with ¾-ton and 1-ton trucks with dump bodies, which are hired locally at the rate of $1.40 per hour for a 1-ton truck with driver. These trucks have proved very satisfactory on this job on account of the central location of the tipple which gives an unusually short haul. Where the haul is not over ½ mile one truck delivers the material as fast as it can be spread by three men. The average haul is about ¾ mile and the hauling cost is about 18 ct. per cubic yard, or approximately 32 ct. for handling from cars to job.

Personals

William Jones has been appointed street commissioner of Hannibal, Mo.

Lee Castleberry has been appointed street commissioner of Denton, Tex.

T. Keith Legore, for the past 3 years city engineer of Columbia, S. C., has resigned and will open an office in that city, specializing in highway and municipal engineering.

H. L. Riley, Minneapolis, Minn., has been assigned as resident engineer to Shiawassee and Clinton counties by the State Highway Department with headquarters in Owosso.

Philip J. Deering, of Portland, Me., who has been chairman of the State Highway Commission for the last four years, has resigned and William M. Ayer of Oakland has been selected to fill the vacancy. Mr. Ayer has been a member of the commission for some years.

John F. Buckner, formerly city engineer of Cleburne, Tex., and more recently assistant engineer with Whittaker & Washington, has accepted the position of secretary of the Rush County Highway Commission, Henderson, Tex., and will have supervision of the construction of a $1,000,000 road system.

Col. Frederick A. Snyder, of Philadelphia, Pa., former city engineer of Williamsport, Pa., and more recently commander of the One Hundred and Third Engineers, Twenty-Eighth Division, has been commissioned a colonel in the Pennsylvania National Guard now in process of reorganization. He will command the First Engineers.

Henry P. Beck, of Richmond, Va.; Frank W. Davis, Lawrenceville; Wade W. Massie, Washington, Va.; Hamee A. Mundy, Jr., Natural Bridge, Va., and Horace Hardaway, St. Paul, Va., have been appointed members of the State Highway Commission of Virginia. Messers. Davis and Hardaway are engineers. The remaining members of the commission are farmers.

Capt. W. V. Buck, formerly city engineer of Junction City, Kan., has been appointed assistant state highway engineer of Kansas. The commission also has appointed three division engineers as provided in the law passed by the last legislature. The appointments are as follows: C. I. Felps, formerly bridge engineer of the State Highway Department, engineer for the eastern division, consisting of 33 counties; Lieut. L. P. Scott, formerly resident engineer on Federal Aid Project No. 11 in Sedwick County, engineer for the northwest division, 35 counties; C. C. Jones, formerly district engineer for Osage and Wabaunsee counties, engineer for the southwest district, 37 counties.

John Ericson, for 22 years city engineer of Chicago, and at present consulting engineer for the Department of Public Works of that city, has opened offices at 820 Otis Bldg., Chicago, and will engage in a consulting engineering practice, specializing in municipal, hydraulic and structural engineering. Mr. Ericson was appointed city engineer on July 6, 1897. Since his appointment as city engineer to Jan. 1, 1919, the following work was done under his direction: Pumping Stations—Remodeled, 4; entirely reconstructed, 2; new, 4. Distribution System—Water mains (6-inch to 48-in.), 1,400 miles; fire hydrants, 20,200; stop valves, 14,150. Water Tunnels—Under Lake Michigan, 15 miles; land tunnels, 39 miles. (Sizes from 5 ft. to 14 ft. inside diameter.) Intake cribs, 5. Developed a Standard Bascule Bridge Design for the City of Chicago, 1898. Bridges Constructed, 1897 to 1919—Movable, 28; fixed, 20. In addition to his duties as city engineer he has served in the following capacities: Member and engineer Board of Local Improvements, member Board of Automobile Examiners, member and chairman Board of Examining Engineers, member and chairman Harbor and Subway Commission, member Commission on Down-town Improvements, member Harbor Board.

Obituaries

Charles H. Swan, a retired engineer of Philadelphia, Pa., died Oct. 7, aged 59. He was formerly engineer in the Bureau of Surveys of Philadelphia and had charge of all work connected with the abolition of grade crossings. He continued in that position until 1905, when he retired.

Prof. John Vose Hazen, a member of the Dartmouth faculty for 41 years, died Oct. 2 at his home in Hanover, N. H., after a protracted illness. The second oldest professor in the college, he had been in retirement since a period of poor health during the summer. He was born in Royalston, Mass., Nov. 27, 1850. After receiving the degrees of BS. and CE. from Dartmouth in 1875 and 1876, respectively, he served as instructor in civil engineering at at Chandler School, connected with the college. Awarded a professorship of theoretical and applied mechanics, he continued on the teaching staff until 1893, when he was chosen as Woodman professor of civil engineering and graphics on the Chandler Foundation. The college conferred an AM. degree on him in 1908.

Industrial Notes

C. W. Cross has been appointed by the Chicago Pneumatic Tool Co. as manager of western railroad sales with headquarters at Fisher Building, Chicago.

The offices of the Service Motor Truck Co. of Wabash, Ind., have just been moved from the building which they have occupied for the last ten years, into a new brick and reinforced concrete administration building three stories high, which has just been completed at a cost of $150,000.

The Production Engineering Co., 212 Centre St., New York, has been organized to act as engineers to manufacturers. The officers of the company are John A. Honegger, president, Robert Steinman, treasurer, and H. Allen Hinchcliff, secretary. The firm will specialize in the designing and building of tools and machinery for automatic production, with emphasis on labor saving devices.

E. J. Dewine, for the past two years in the construction division of the Army, has joined the permanent forces of the International Exposition of Municipal Equipment, Grand Central Palace, New York, and will have charge of the department of streets, asphalt and road machinery. J. H. Brewster, a sanitary engineer who since his discharge from the Army has been identified with the engineering department of the New York State Board of Health, also has joined the permanent forces of the exposition and will have charge of the health, water, sewage disposal and milk sections.

Announcement has been made of the sale of the plant of the Knox Motors Co., Springfield, Mass., to Neil R. Sinclair of New York, president of the Militor Motors Corporation. In disposing of the plant, the Knox Motors Co. reserves the right to use a part of the buildings for its needs for a period of two years. The Knox Motors Co. has been identified with the motor industry since its infancy and will continue the manufacture of its present products as well as parts for its former models at the Springfield plant. It is understood that the company has plans under consideration which will increase and round out its present lines.

Waterworks and Hydraulics Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field if subscribed for as a weekly at $3.00 a year; but anyone of the four special monthly issues may be subscribed for as a monthly at $1.00 a year (or any two monthly issues at $1.50 a year) and the 4 special quarterly issues will be sent without extra charge. Three of these special quarterly issues relate entirely to foreign engineering and construction practice and the fourth is our annual "New Equipment Issue." The *articles* in the first two issues of each month (1st and 2nd Wednesdays) completely cover the municipal engineering and contracting field. The *articles* in the first and last issues of each month (1st and 4th Wednesdays) completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and last issues of each month (3rd and 4th Wednesdays) completely cover steam and electric railway location, design and construction. See the "mast head" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging (c) Quarries and Pits
(b) Rivers and Canals (d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings (c) Harbor Structures
(b) Bridges (d) Miscellaneous Structures
(e) Properties of Materials

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Self-Satisfaction Causes Ignorance and Slackens Progress

"Taken as a whole, they are a fractionally informed, complaisant lot." When an expression like this casually reaches the ear one's curiosity is aroused. To what "lot" is the speaker referring? The voters at the last election? The workers in a factory? The trustees of a school board? Traveling salesmen? Directors of a corporation? The mind of the questioner flies to many a class, but always to some class other than the one to which he belongs. Inherent egotism invariably makes us think of the other fellows when any generalization is uttered about the relative ignorance of a class of men.

Let some one mention the general lack of education of a certain nation, and how many Americans will instinctively think that their own nation is meant? Let it be said that a certain profession consists of relatively ignorant men and how many engineers will automatically think that engineers are meant? Not one in a hundred. Human beings are instinctively and excessively self-satisfied. Were they not, the world would be manyfold wealthier, and, let us hope, happier than it is.

We engineers, and especially those of us that have had a college course in engineering, are of one flesh with the rest of men in our self-esteem; for most of us fancy that we are pretty well informed and up to date professionally, at least in that branch of engineering in which we specialize. But are we? Have we ever put ourselves to a quantitative test to justify our high self-rating in the scale of professional knowledge? Has it ever occurred to us that if we were cross-examined by, say, ten of the best informed specialists in our field, we might be shown to be miserably lacking in knowledge needed for the most efficient performance of our daily tasks?

The editor has chanced to see many celebrated engineers under cross-examination as expert witnesses, and rarely has he seen any of them stand up well under a grilling questioning that involved a detailed knowledge of their specialties. Often there has been an abject breakdown and confession of ignorance of matters that should have been known offhand. At such times, the excuse has usually been offered by the great man that he left "details" to his subordinates. Under the broad term "detail" the great man usually classes all that he does not know about his professional work. Details there are, to be sure, which no man can remember, but hundreds of facts that should be known are thrown into this catch-all excuse basket, as mere "details."

The truth is that no engineer is thoroughly well informed, not even the youngest of us. By the side of the best informed engineer in any given specialty, probably the average engineer in that field would not be able to show a knowledge rating 40 per cent. By the

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

side of the ten best informed specialists, we doubt whether the average specialist would rate as high as 15 per cent in needed knowledge. Yet most of us go about rather well pleased, instead of profoundly dissatisfied with our knowledge.

What evidence is there that leads to such a pessimistic conclusion? It is to be found on every side, if we will but look, but, best of all, it is to be found by every man in himself. Introspection will furnish abundant proof, if we but treat ourselves as relentlessly and searchingly as we might be treated under a severe cross-examination conducted by experts in our specialty.

Are you familiar with surveying? Feel perfectly competent personally to direct a survey of a highway, for example? Yes? Competence to direct, you will grant, involves knowledge of the most economic available methods and devices Very well, then, what is the most economic method and device for cross-section leveling? This is not an idle query; we are putting it to you for answer, if you are one who feels himself able to direct a survey. And we feel confident that not one civil engineer in a hundred can answer this simple question correctly, unless he read in our Nov. 5 issue the article entitled "Use of a Self-Computing Level Rod in Highway Surveys," by R. T. Brown, Chief of Surveys of the State Highway Department of South Carolina. Lest you reply that this is an unfair test because of the recency of this article, we must tell you that Mr. Brown refers in his article to a published description of the endless-tape leveling rod designed by H. P. Gillette, in Engineering News, Sept. 13, 1900, nineteen years ago. Sixteen years ago Gillette's "Earthwork and Its Cost," containing this same description, was placed on sale and has been on sale ever since. Mr. Brown says: "But due partly to our conservatism in following long used methods, and partly to the fear of introducing new sources of error into leveling operations, we have neglected to take advantage of this time and labor-saving principle."

Mr. Brown has not fully stated the fundamental reason why this time-saving leveling rod is so rarely used. The fundamental reason is ignorance, an ignorance that springs from self-satisfaction. The average civil engineer thinks that he knows the best way to take cross-section levels. He makes no search for a better way, or, finding what is really a better way, he gives it no test. In the latter case, he usually reasons deductively upon assumed premises and comes to a false conclusion. Thus, he may say to himself: If this endless tape leveling rod is as good as it is claimed to be, after all these years it would surely have come into more general use. Since it is not in general use, it must be no improvement over the old kinds of leveling rod. Or he reasons thus: By graduating the tape on the rod from the top downward, all computation in leveling is eliminated, but computing "height of instrument" and elevation occupies so small a time that the risk of error in using this unusual type of rod more than offsets any gain in time. This line of reasoning is one that the editor has frequently heard. It is purely hypothetical deduction, for it assumes as true what is not true, namely, that the time spent in computation of elevations and H. I. is nominal.

The majority of civil engineers have never read about this level rod. Most of the minority that have heard of it have not investigated it; and of those that have "investigated" it, only a very few have carried their investigation to the point of an actual test, having relied on deductive reasoning from assumed premises. This last named act is largely the result of failure to make a careful study of logic and logical methods, and that, in turn, springs from confidence in one's ability always to reason correctly without having studied logic, the science of reasoning. So, from whatever angle we view this general failure to use this labor-saving device, we see that complaisant self-satisfaction is the outstanding cause.

To any engineer who regards the above example as an extreme case, not typical, we suggest the following test: Take the last 12 volumes of this periodical, or of any other that contains many useful articles relating to a given subject in which you regard yourself as well informed. Spend half an hour on each volume, going through it page by page, recording only those articles that seem to contain useful information. This reconnaisance over a six year period of a weekly magazine will consume about one full day. Then follow it by reading and very briefly abstracting the worthwhile facts of each article for the purpose of securing a personally made index. Having made this "contour map" of the six-year field, ask yourself whether you are not far better equipped to solve economic problems in that field than you were before you made the "survey." There can be one only answer —that the editor knows from his own experience in writing books. But the editor's recital of his experience can never make the imprint on your mind that your own experience will make. Do this thing, or something like it, yourself. See for yourself that you are really ignorant, in your own specialty. Such a revelation may be the only influence that you need to dispell the grand illusion that makes men mediocre—the illusion that they are pretty well informed.

Was it not Isaac Newton who said, shortly before the close of his wonderful life: "I feel that I have been like a child gathering colored pebbles along an ocean shore, so numberless are the facts that I know not, so few the number that I know."

That is the attitude of mind that every thorough searcher for information inevitably comes to have; and coincidently there vanishes nearly all, if not all, vanity over one's personal knowledge or achievements. How miserable seem our own pickings from the little crab-apple tree of knowledge that we have personally brought to fruition. How vast the orchards that other men have planted. How immeasurably vaster the acres remaining to be covered.

Why the Government Should Regulate Coal Consumers as Well as the Miners and Operators

Bituminous coal miners have averaged a loss of 28 per cent of the working time during the past eight years, mainly because mine operators have not kept the mines operating at a uniform rate, or, as electrical engineers would say, at 100 per cent load factor The mine operators blame the coal consumers for this condition of affairs, stating that most of the public lives from hand-to-mouth, or, rather hand-to-stove, and will not order coal much in advance of current needs. This is not a new condition of affairs. The writer wrote an editorial on this subject for Engineering News, Nov. 13, 1902, and urged a careful study of this economic problem. Now that a great strike has brought the matter to public attention, there is some prospect that this problem may be solved.

The miners propose to solve it by working only 30 hours a week. They claim that during 1918 when 80,000 coal miners were in the army, the remaining 90 per cent produced 15 per cent more coal than is normally produced. Now they propose to furnish continuous work for all the miners by reducing the weekly number of work hours. This is not so foolish a solution of the problem as might appear at first glance. Indeed, it is quite reasonable, and would meet with little or no opposition were all workers able to enjoy a 30-hour week and at the same time produce as much per annum as they have been accustomed to produce. We do not doubt that this very thing could be done were workers and managers to cooperate in putting it into effect; but a great deal of educational work lies ahead before that can be accomplished. In the meantime what can be done to increase the "load factor" of the coal miners?

It has been suggested that freight rates on coal be made lower during the spring and summer months, in order to secure orders enough to keep the miners busy during those months. But this is open to the objection that most people live from hand-to-mouth and do not bite at the bait of lower prices for things that they do not need immediately. Certain it is that a seasonal ten per cent reduction in the price of coal has not served to cause many householders to stock up during the spring and summer months. It has been suggested that the coal ordered and stored early in the year be billed in the fall of the year, without interest charge. But who is to foot the bill for interest? The coal operators are not likely to do so, except under government compulsion There is the further objection that bituminous coal deteriorates gradually (about 2 per cent the first year) when stored in the open air. Subaqueous storage is practicable only on a large scale.

Like every economic problem, this one contains many factors, but it is peculiarly complicated by the fact that the control of all the important factors is not in the hands of any one man or of any group of men. Nor does there seem any likelihood of such a unified control coming about through ordinary industrial evolution. The public is not likely to permit a great corporation to secure control of most of the coal mines. If not, there is no escaping the conclusion that the government itself must take some sort of action that will result in central control of all the main economic factors. This does not necessarily mean government ownership of the coal mines, but it does mean regulation of their management, somewhat analogous to the regulation of railways and other public utilities. It means that, and perhaps it means more than that.

If the government should undertake to regulate the coal producers, why should it not regulate the coal consumers? If by their hand-to-furnace habits of ordering coal, the consumers have caused coal miners to be idle 28 per cent of the time, surely the government, in the interest of social economy, should make the consumers abandon this habit. The most practical way of regulating the ordering of coal by consumers need not be discussed in this article, the main object of which is to present the thought that coal consumers are quite as much in need of government control as are coal operators and coal miners. These three human factors in this economic problem must be made to cooperate if there is to be the maximum of economy. Hitherto each of these three factors has acted mainly with respect to its own interests. The same, of course, may be said of many another industry, but in the production of coal we have one of the worst examples of the waste of human effort because of the absence of complete cooperation. The result is precisely the same as if an army of about a quarter of a million men were constantly idle. Here is Congress hesitating as to whether we really need a standing army of 375,000 men, when more than two-thirds that number of men—coal miners—have been idle every year except the year 1918. The tax that is paid to support an army of idle coal miners every year is paid in the form of higher prices for coal, and is thus hidden from sight.

The government can eliminate this idle time tax by requiring all coal consumers to store a part of the coal they use. This would reduce the total number of coal miners by about 25 per cent, but, as there is a steadily growing demand for workers, no hardship would be incurred by the discharged miners, provided the government were to undertake to train them for new positions. This last proviso is important. In fact it is probably essential, for workmen rightly resent being thrown out of employment The speed with which skilled workmen can be trained was not generally realized until the war made it necessary quickly to train ship builders, munition workers and what not.

Let the government, therefore, train the excess number of miners for new jobs, paying them their regular wages during the training period. Put the remaining miners on a 44-hour week basis, and require the mine operators to pay them a uniform weekly wage throughout the year, just as office employes are now paid. This will stimulate the mine operators to keep their men continuously busy. Finally, let the government require all coal users to submit schedules of their coming year's total requirements, and accept uniform monthly deliveries thereof, except in certain special cases. By this tripartite regulation of the miners, the operators and the consumers, great economy in the production of coal will be secured. Moreover, there will be a similar decrease in the cost of transporting coal by rail.

Think About Thinking

Relatively few men, even among those called educated, have studied any text book on logic. Of those that have studied logic apparently few have formed the habit of studying their own methods of thinking. Nearly all who have read logic seem to regard it as being like grammar in respect of the reader's ability to learn at once for all. Hence it comes about that very few thinkers think about thinking, just as relatively few writers think about grammar. This unfortunate attitude toward logic is partly due to the mistaken belief that the mind needs no special training in order to draw correct inferences from facts, and it is partly due to the teachers and text books on logic.

Aristotle, the father of logic, was a grammarian before he became a logican. His "syllogisms" are essentially nothing more than systems of wording premises and so "combining" them as to draw conclusions. Viewed in this light the deductive logic of Aristotle is a sort of glorified grammar, a system that leads to a correct use of words in deductive reasoning. While it can not be denied that the systematic use of language is a great aid in reasoning, it should not be inferred that deductive logic involves nothing more than syllogising, yet none of the text books on logic undertakes to go much beyond the very limited realm of the syllogism in discussing deductive reasoning. This is a great mistake, and it is one that has done more to bring logic into neglect than can be estimated.

John Stuart Mill wrote the first edition of his celebrated "Logic" about 70 years ago. While he admittedly added nothing of any consequence to deductive logic, he claimed to have systematized inductive logic for the first time. His conception of induction was the old one of drawing a broad generalization from the observation of particular instances, e. g., All men are mortal. He thought it the particular province of inductive logic to establish the laws of nature, and to this end he formulated "four experimental methods" or "canons." He boldly proclaimed these to be all the methods that could be conceived, which, if true, would tend to close the door of progress quite as effectively in the field of inductive logic as it had presumably been closed by Aristotle in the field of deductive logic. Mill said: "These four methods which it has now been attempted to describe are the only possible modes of experimental inquiry; at least, I know not, nor am able to imagine, any others."

Bain and other logicians have accepted this dictum, and to this day there has been no serious attempt to combat it. But if "logic is the science of sciences," as Mill himself called it, and if science is steadily advancing, is there not an incongruity in the statement that Mill's "canons" and Aristotle's "syllogisms" embrace all the fundamental principles of correct thinking? The fact is that logic has been a "dead science" these 70 years mainly because it was not born a science, and not even Mill breathed the spirit of science into its body.

Consider a few of the outstanding scientific discoveries that have occurred since Mill penned his first edition in 1848: (1) Discovery of the mechanical equivalent of heat, which lead to the grand discovery of the indistructibility of energy. (2) Enunciation of the theory of evolution. (3) The discovery of bacteria as the causes of most diseases. (4) The birth of physical chemistry. (5) The revolutionary discoveries of X-ray and radium emanations, which have led to many changes in our conception of matter and energy.

Any well read engineer who studies Mill's logic today can hardly fail to be impressed by the great handicap of ignorance of science under which Mill labored. Nor can the conviction be escaped that Mill erred badly in assuming that he had said about the last new word that could be said on logic.

Boole invented his symbolic or equational logic shortly after Mill wrote his first edition, and for a time great hope was aroused in his desciples that his methods would revolutionize deductive logic; but the hope has remained unfulfilled. The principle merit of symbolic logic is that it gives a somewhat better grasp of the syllogisms, and serves to bring out the truly symbolic nature of deductive reasoning even where words are used. Aside from Boole's work there has been no noteworthy advance in logic in 70 years, yet Boole furnished a method that has only a narrow field of application. Some day this inactivity of the "science of sciences" for 70 years will astonish scientific historians.

Few of us who are professional thinkers have been in the habit of analyzing our own methods of arriving at conclusions. And only a few of these few have written about their thinking processes. In short we are not habituated to think about thinking. Burbank's great book is peculiarly illuminative, because he describes not only his methods but certain of his reasoning processes. Unfortunately he has not studied logic as such, and therefore is not as clear as he might have been in outlining his system of reasoning about the creation of new plants. Our other great thinkers have been even less inclined than Burbank to self-analysis of their methods of thinking. Were Edison to describe in detail his systems of thinking, we do not doubt that he would greatly aid all inventive minds. He might show how an average mind could become highly inventive. Indeed it is not improbable that he would enrich posterity far more by publishing a searching analysis of his mental methods than by making his most cherished invention.

Think about thinking, that is about all the mental processes, mechanical aids and systems of arriving with celerity at correct conclusions and creative ideas.

Reasoning of every kind, whether deductive, inductive or creative, is impossible without memory. Other things being equal, the man with the best memory is the best reasoner. So, study the art of memorizing, and to do this read psychology. Learn the relative importance of the three great factors in memorizing, (1) vividness of impression, (2) repetition of impressions, and (3) association of different impressions. Study your growing power of remembering facts relating to your own specialty, noting especially the accelerated growth of that power when you carefully analyze and compare the data. Observe, then, the increase in your ability to reason both correctly and creatively as your store of memorized facts increases. Should you go no farther than this in thinking about thinking you will be well rewarded, for you will come to have a respect for memory that relatively few educated men now have, and with that respect will come a determination to store your mind with usable information.

If you think long enough about thinking, you will finally see plainly that the process of qualitative deduction is fundamentally a process of remembering. Then it follows that the deductive inference that is called "foresight" is itself a process of remembering, or "hindsight." The inexperienced child, lacking a memory of dangers, runs into danger—shows no foresight. Similarly with all inexperienced people, be they young or old.

Memory may relate to personal experiences, or to the narrated experiences of others, or to the place where recorded experiences may be found. Facts are equally valuable, regardless of their source, provided they are available as data with which to reason. But "time is the essence of the contract," so he that has the facts in his head is better than he that has them in his library.

Results of Malaria Mosquito Survey in Northern California

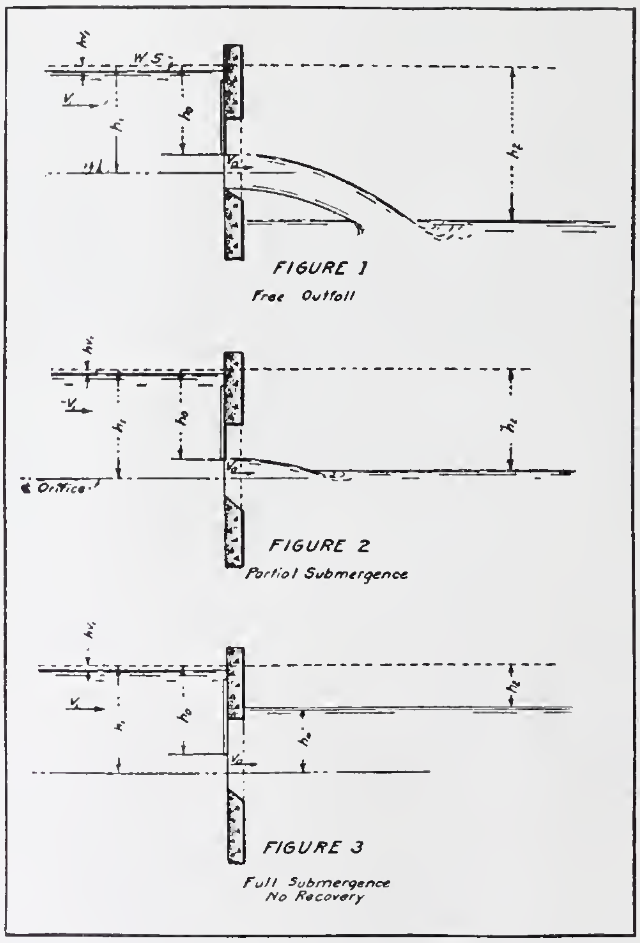
During the past 10 years, California has rid itself of at least 60 per cent of malaria. This is due principally to the state-wide campaign against the malaria-carrying mosquito known as Anopheline, according to a recent bulletin issued by the State Board of Health of that state. Since 1916 the State Board of Health, in co-operation with the University of California, has been making a survey of the state with the objects of obtaining accurate knowledge of the distribution of the malaria carrying mosquito, to determine methods of control, and to educate the public by lectures and literature. The territory covered thus far includes the northern third of the state where 58.7 per cent of the malarial deaths from 1909 to 1918 have occurred.

The results show that two out of every five mosquitoes captured were at least potential carriers of malaria. In the Sacramento Valley counties 52.7 per cent of all mosquitoes collected were Anopheline. Considering only counties with a high malaria rate, there have been reductions varying from 63 per cent to 85 per cent in the death rate for the 5-year period from 1914 to 1918, as compared with the previous 5-year period, 1909 to 1913 inclusive. This actually means that there have been about 125 lives saved in that period and probably 50,000 cases of malaria prevented.

Another interesting phase is the economic loss from malaria in districts where irrigation has been recently introduced. According to Mr. Harold F. Gray, State District Health Officer, in a recent report to the California State Board of Health printed in the Journal of the American Medical Association, the introduction of irrigation caused an economic loss due to malaria of $31.70 per family for medicine, medical service and labor loss in 1918. The district in which this occurred was the Anderson-Cottonwood irrigation district, comprising about 32,000 acres along the Sacramento River and having a population of about 1,300. Ideal conditions for the breeding of Anopheline mosquitoes were created by the seepage from the canals and laterals. Of 1,081 persons, 590 or 54.5 per cent had malaria symptoms. The cost per family for the year was $5.70 for medicine, $7.10 for medical services, and $18.90 for labor loss, making a total of $31.70. This amounted to $7.66 per capita or $14.05 for each sick person. With the drainage and mosquito control work carried out as planned it is estimated that reduction of malaria amounting to 95 per cent may be expected in four years.

Discharge Coefficients for Canal Head Gates

The first consideration in regard to a canal head gate is that its capacity shall surely be equal to the demand that will be made upon it. The next consideration, and almost as vital, is its cost. Every foot saved in width means many dollars saved the water users; a foot saved in depth may mean several times as much; a few tenths saved here and there in head through gates and other structures is translated into acres covered that otherwise might be left above the ditch. A logical and practical method for the study of capacity as related to existing head gates and the application of results obtained to the design of future structures, is outlined by J. S. Longwell and Julian Hinds, Engineers U. S. Reclamation Service, in the October Reclamation Record, from which the matter following is abstracted.



Figs. 1 to 3.

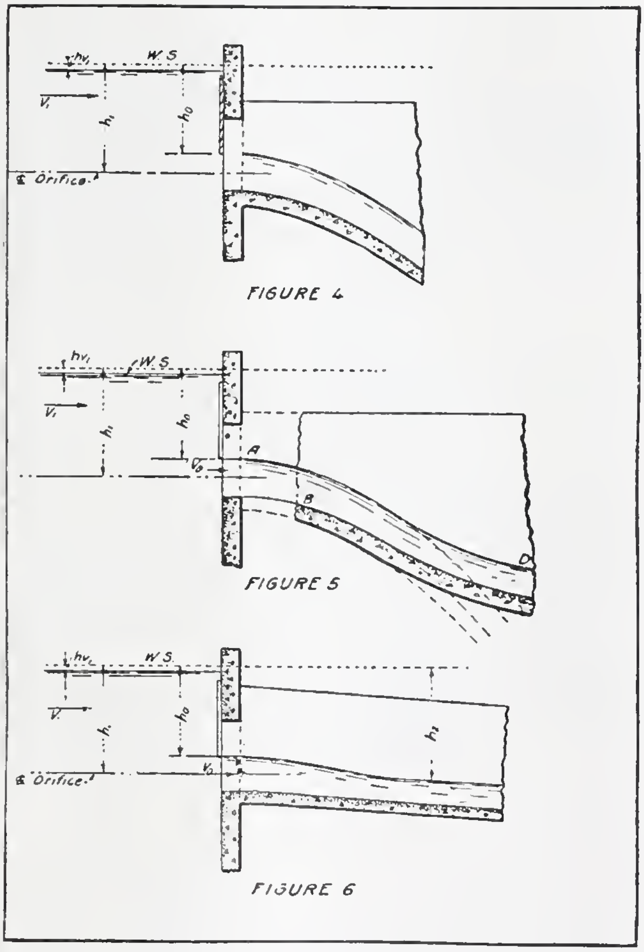
The discharge of orifices in general, both submerged and with free outfall, has been extensively discussed in textbooks and published articles on hydraulics, but there are a number of points in connection with the discharge through canal headgates as a special form of orifice which have not been covered in the published literature on the subject as fully as might be desired.

It has been established that the discharge through thin-edged orifices and short tubes is given with sufficient accuracy by the formula $Q = AC\sqrt{2gh}$, where Q is the discharge, A is the area of the orifice, C is a coefficient determined by experiment, and h is the effective head. If A is measured in square feet and h is given in feet, the discharge Q is obtained in second-feet. It is the purpose of this discussion to point out the limitations to be observed in the application of this formula to the computations of discharge through canal headgates in installations similar to those shown in Figs. 10 and 11, and to develop a logical method for determining the value of C and the effective head to be used with such structures. It is assumed the form of equation as given above is satisfactory.

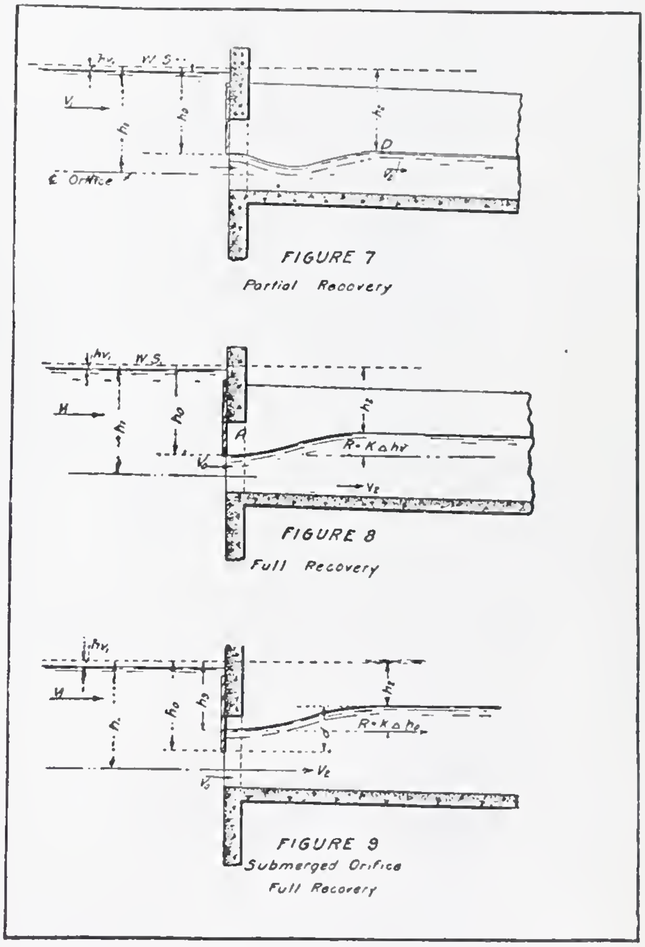
The following notation is used throughout the discussion:

V_1 = Velocity of approach.
V_0 = Velocity through orifice.
V_2 = Velocity at point of maximum recovery in canal.
hv_1, hv_0, and hv_2 = Velocity heads corresponding to V_1, V_0, and V_2, respectively.
h_1 = Head on center of orifice, including hv_1.
h_0 = Head on top of orifice, including hv_0.
h_3 = Drop through orifice, including hv_1.
h_2 = Drop from above gate to maximum W. S. in canal below, including hv_1.
h_4 = Back pressure on center of orifice.
d = $h_0 - h_2$.
Q = Discharge in cubic feet per second.
A = Area of orifice.
C_0 = Coefficient of discharge computed from h_0.
C_3 = Coefficient of discharge computed from h_3.
C_2 = Coefficient of discharge computed from h_2.
C = Coefficient of discharge.
hf = Friction head through transition.

The velocity is assumed to be the mean velocity at the point under consideration, no allowance being made for the unequal distribution of velocities throughout the cross section. The effective head is in all cases assumed to include the velocity head due to the velocity of approach (hv_1).



Figs. 4 to 6.



Figs. 7 to 9.

Typical discharge conditions are illustrated in Figs. 1 to 9, inclusive. Figs. 1, 2 and 3 represent ordinary orifice discharge as discussed in all treatises on hydraulics. It is assumed to be established that the effective head for the condition in Fig. 1 should be measured to the center of the gate for ordinary accuracy. Likewise the head for Fig. 3 should be measured to the water surface below the gate. Formulæ for Fig. 2 and precise formulæ for Fig. 1 will be found in any standard treatise on hydraulics.

In previous analyses of flow through headgate, h_2, the drop from a point above the gate to the water surface at the point of maximum recovery below the gate, has been taken as the effective head and a corresponding discharge coefficient computed. Such experimental data as are available indicate that this coefficient is not constant, and Fig. 4 to 9 inclusive are intended to show that a constant coefficient based upon the head h_2 can not be obtained. In order to reduce the variables to a minimum the intake and approach conditions are assumed to be identical in all cases. In Figs. 1, 2 and 3 the sides of the jet are assumed to be unconfined by walls, the discharge being into an open pool. In Figs. 4 to 9 inclusive the bottom and sides of the transition are assumed to fit the orifice at the head wall and to gradually change to the cross section of the canal.

Flow is in all cases produced by the resultant of the head tending to force the water down stream and the back pressure tending to hold it back. In Fig. 1 the jet is free to fall as soon as it has cleared the orifice, hence there is no back pressure. In Fig. 2 the lower part of the jet is supported by flotation, and there is back pressure on the submerged portion of the orifice. In Fig. 3 the average back pressure is equal to h_4 and the net effective head is h_2, the drop in water surface through the gate plus the velocity head of approach.

In Fig. 4 an outfall channel is fitted to the orifice. If the sides and bottom of the channel are made to conform exactly to the sides and bottom of the freely falling jet, Fig. 1, no alteration of the flow will occur. If, however, the form of the channel is such that the jet is held up above its free fall trajectory, a portion of its weight will be supported by the bottom of the channel. A portion of the weight of each particle of water will be supported by the particle below, and a partial hydrostatic pressure will result, producing a back pressure on the orifice. In order for this back pressure to be effective in reducing the discharge through the gate the holding up of the jet must begin at the orifice. This is illustrated in Fig. 5. Assume a gap left in the channel between A and B, the point B being located so that it just catches the freely falling jet. Although the jet is held up above normal at D, the resulting hydrostatic pressure clearly has no effect on the flow at A. Filling the gap in the channel will not alter the results.

Figures 6 and 7 represent conditions in which the outlet channel is such that the jet, immediately below the orifice, is held up above its free fall trajectory. The water particles are falling slightly as they leave the orifice and the effective head is more than h_0. However, if the free fall of the jet is materially interfered with at A, nearly the full weight of the stream will be supported by the bottom of the channel and the effective head will exceed h_0 by only a very small amount. In design this slight increase may safely be neglected. In the discussion of experimental data the increase may be neglected without serious error unless conditions approximate those shown and discussed under Fig. 5.

Figures 8 and 9 show a transition section fitted to the orifice flow conditions in the channel below the transition such that the water surface begins to rise after passing through the orifice. This rise represents the recoverable portion of the change in velocity head between the orifice and the channel below the transition. There is a definite limit to the proportion of the change in velocity head between the orifice and channel which may be recovered with a given form of transition. It is generally assumed that this maximum recovery is represented by $k\triangle hv$, where $\triangle hv$ is the change in velocity head and k is a constant depending upon the form of transition. In figure 8, R is assumed to be equal to $k\triangle hv$, so that if the water surface at D be raised, due to change in regimen of channel below, the orifice will become submerged at A and the conditions shown in Fig. 9 will exist. If the water surface at A is lowered conditions will be similar to those shown in Fig. 7. There can be no pressure head above the top of the opening at A, Fig. 8, since the orifice is not submerged, and since the jet is clearly not falling, there is hydrostatic back pressure equal to the depth of the orifice and the effective head is h_0. In Fig. 9 the back pressure is equal to the depth of water just below the orifice, and the effective head is h_3.

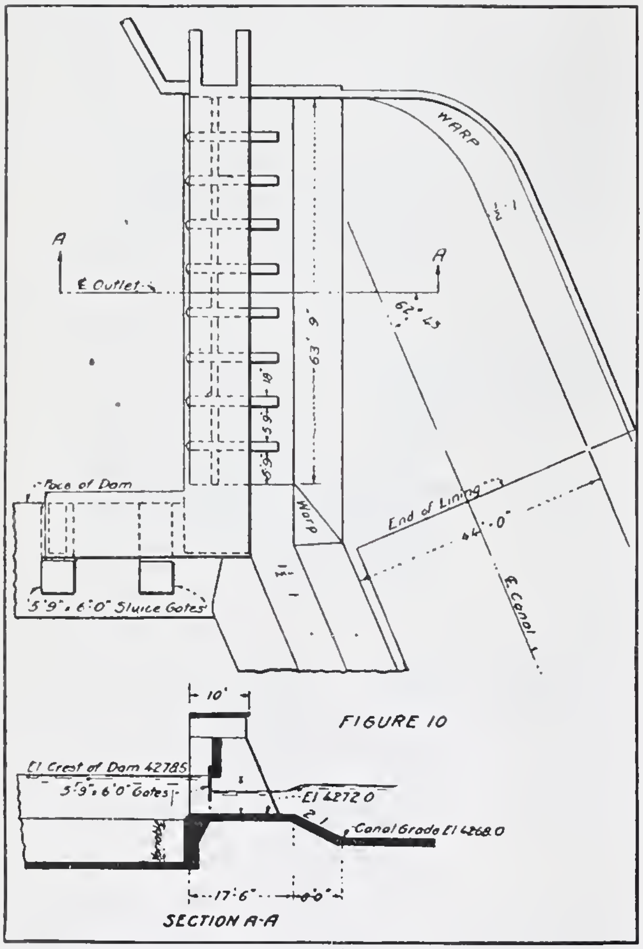


FIGURE 10

Whalen Headgates, North Platte Project.

Figures 6, 7 and 8 show that for a wide range in outlet conditions the discharge remains sensibly the same, while h_2 may be equal to or greater than h_0, or with inlet and outlet approaching perfection and with proper regimen in the channel below, h_2 may approach zero as a limiting value. It is thus evident that a coefficient of discharge based upon h_2 must vary with the outlet conditions as well as with the form of orifice. The value of this coefficient will be affected by the required elevation of water in the channel below the transition, as well as by the form of the transition. Recovery can not take place to a greater elevation than the normal water surface in the channel below, regardless of the recovering capacity of the outlet.

Headwork structures for canals are usually constructed along definite lines and may be grouped into a few distinct classes having similar inlet conditions and approximately equal recovery coefficients k. The relative elevations of the top of the orifice and the normal water surface in the canal are likely, however, to vary widely and flow conditions may vary through the entire range from Fig. 6 to Fig. 9. In design this variation should properly be provided for by using the effective head h_0 or h_3, obtained as outlined above, with an experimentally determined value for C. Flow conditions below the orifice should be determined separately, from the known or assumed value of K and the hydraulic properties of the canal. The effective head h_3 may be found by adding $k\triangle hv$ and the friction loss in the transition to h_2 h_2 and $\triangle kv$ being known and k being assumed from experimental data on similar transitions. If h_3 as thus computed is greater than h_0 design for h_0.

In experimental work flow conditions will vary from those shown in Fig. 6 to those in Fig. 9, for varying discharges through the same structure, since the canal depth will never vary exactly as the height of gate opening under all conditions of head water. A coefficient of discharge based upon h_2 will therefore vary widely for the same structure under varying conditions and is valueless. The discharge coefficient should be based upon the head h_0 or h_3, h_3 being in all cases observed and not computed. Measurements should also be taken from which to determine the value of k, the friction in the transition and other special losses. It will usually be impracticable to separate the losses occurring in the transition, in which case the friction may be estimated with sufficient accuracy, and all other losses may be included in the value of k. A careful distinction should be drawn between cases in which the recovery is produced by gradual expansion, and cases involving the hydraulic jump. A lower value of k may be expected where the jump occurs.

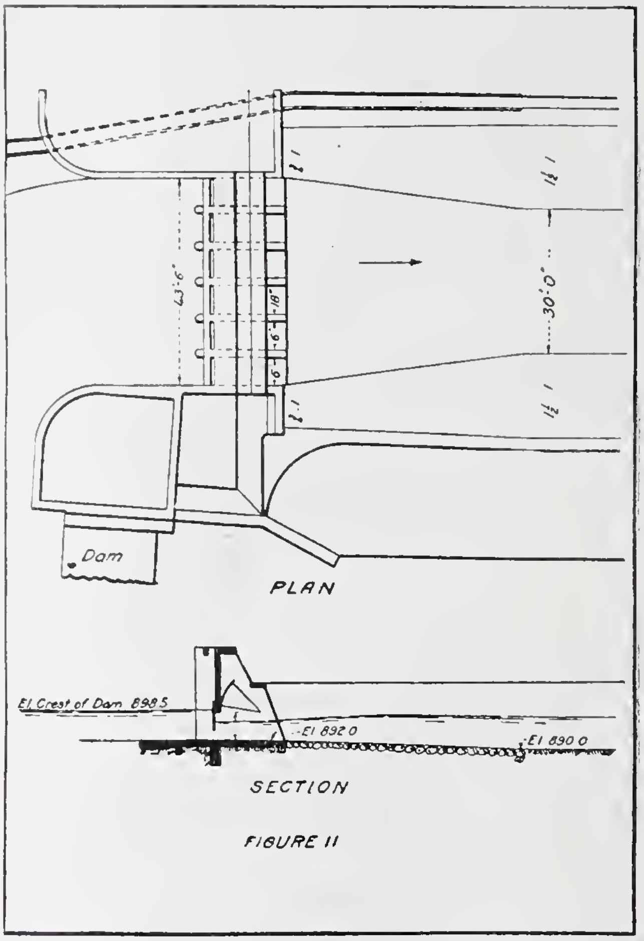


FIGURE 11

Sunnyside Headgates, Yakima Project.

A number of observations made at the Whalen headgates on the North Platte project and at the Sunnyside headgates on the Yakima project by the United States Reclamation Service are analyzed in Tables I, II and III. The Whalen headworks consist of nine 5-ft. 9-in. by 6-ft. cast iron gates separated by 18-in. piers, as shown in Fig. 10. Only observations in which at least eight gates were open are included in the table. The Sunnyside headworks consist of six castiron gates separated by 18-in. piers, as shown in Fig. 11. Unfortunately only the head h_2 was measured in these experiments and it was necessary to compute h_3 by indirect methods. The observations for the Whalen gates are arranged in the order of ascending values of d/△hv and a value of k is found by trial which gives the same average value of C for partial recovery (using h_0) as for full recovery (using h_3). The value of k thus determined for the Whalen gates is 0.62. All Sunnyside gates appear to be under full recovery and there is no basis for determining the value of k. A value of 0.70 is assumed and the resulting discharge coefficient is the same as for the Whalen gates. The average value of C is found to be 0.72. No great dependence can be placed upon the results derived from these experiments, since the head h_3 was not measured in the field. It was also necessary to estimate the friction loss from A to D and the velocity head at D. The table is given for illustration only.

The values of C_2 as originally computed are shown for comparison. It may be noted that in certain cases C_2 was found to be greater than unity. These observations were originally thrown out on the assumption that values of C_2 greater than unity are impossible. This assumption is incorrect and these experiments should be retained. For example, assume a bell mouth entrance with a coefficient of 0.95 and an expanding outlet which will recover 0.90 of the velocity head through the orifice, the velocity above and below the structure being assumed zero, then

$$V_0 = .95\sqrt{2gh_3}$$

$$ev_0 = \frac{V_0^2}{2g} = .90h_3$$

$$\text{Recovery} = 0.90hv_0 = .81h_3$$

$$h_2 = h_3 - .81h_3 = .19h_3$$

$$V_0 = .95\sqrt{2g\frac{h_2}{.19}} = 2.20\sqrt{2gh}$$

$$\text{or } C_2 = 2.20$$

Values of C_2 as high as this can easily be produced and values greater than unity doubtless often occur in practice.

In all future experimental work on the flow through headgates, it is suggested that the value of h_3 be obtained in the field. To do this it will probably be necessary to install a gage or well connected with the floor directly downstream from the gates. This will be particularly necessary in the case of full recovery with the hydraulic jump, in which case there is much disturbance on the downstream side of the gates and on account of the air in the water the actual water surface elevation will not represent the true hydrostatic pressure. The value of h_2 and of d should also be obtained. The gate opening, velocity of approach, velocity of water in canal at D, discharge and other hydraulic data should be taken. All gates should be opened the same amount so that flow conditions will be as uniform as possible entirely across the channel.

From the data obtained, the various experiments should be grouped, as explained above, and the values of C and k computed. Detailed tabulations may then be prepared giving the values of C for various gates and values of k for various types of transition sections.

In the design of canal headgates the maximum elevation of the water surface in the canal and the minimum water surface above the headgates are usually established and the required discharge is known. With data at hand, the value of h_0 may be computed. From experimental data available, the value of k for the type of transition section which it is proposed to use may be determined. From a similar source the proper value of C for the type of gate installation may be selected. Assumptions may then be made as to the size and setting of the gates and h_3 computed from formula $h_3 = h_2 + k(hv_1 - hv_2) + hf$. In this computation it should be understood that h is not to exceed h_0. Knowing C, h_3, Q and h_0, the area of gate opening may be computed and compared with that assumed and the necessary adjustments of assumption made and the area revised if necessary.

It is believed that by the use of this method the chances for errors in design due to changing conditions of flow in the canal will be minimized and that a more rational design will result in every way than would be obtained by the use of the overall coefficient C_2.

TABLE I—WHALEN HEAD GATE, PARTIALLY SUBMERGED.

Exp. No.	No. gates open.	h_0.	h_2.	hv_1.	hf.	Δhv.	e.	Q	V_0	$\sqrt{2gh_3}$.	C_3.	C_2
49	8	6.10	5.9	0.0	.24	3.07	.14	659	14.32	19.81	.72	.74
12	9	6.30	5.7	0.0	.32	3.05	.30	628	14.27	20.13	.71	.75
25	8	6.20	4.7	0.0	.12	2.81	.59	964	13.96	19.97	.70	.80
95	9	5.94	4.45	0.0	.26	2.92	.60	776	14.20	19.53	.73	.84
13 other items omitted for lack of space.												
Average of 17 items											.72	.79

TABLE II—WHALEN HEAD GATE, FULLY SUBMERGED

Exp. No	No. gates open.	h_0.	h_2	hv_1	hf.	Δhv.	e.	R=0.62Δhv.	h_3	Q.	V_0.	$\sqrt{2gh_3}$.	C_3.	C_2
35	8	7.20	5.2	0.0	.16	3.33	.65	2.05	7.09	1,161	15.28	21.3	.72	.84
45	8	6.40	4.4	0.0	.09	2.84	.74	1.76	6.07	1,081	13.83	19.7	.70	.82
63	8	7.95	4.5	0.0	.05	4.24	.83	2.63	7.08	1,154	16.73	21.3	.79	.98
44	8	5.35	3.1	0.0	.04	2.25	1.02	1.40	4.46	1,349	12.46	16.9	.74	.88
21	9	5.95	2.1	0.0	.02	2.31	1.67	1.43	3.51	1,428	12.53	15.0	.84	1.08
63 other items omitted for lack of space.														
Average 68 items													.72	.85

TABLE III—SUNNYSIDE HEADGATES, FULLY SUBMERGED.

Exp. No.	No. gates open.	h_0.	h_2.	hv_1.	hf.	Δhv.	e.	R=0.7Δhv.	h_3.	Q.	V_0.	$\sqrt{2gh_3}$.	C_3.	C_2
3	6	5.17	2.06	.08	.11	1.14	2.83	.80	2.83	724	9.54	13.5	.70	.81
24	6	6.22	2.92	.06	.13	1.79	1.92	1.25	4.10	650	11.55	16.2	.72	.84
25	6	7.02	3.50	.06	.13	2.08	1.75	1.46	4.89	760	12.39	17.7	.70	.82
54	6	4.02	1.77	.15	.10	1.00	2.35	.70	2.52	906	9.34	12.7	.73	.84
77	6	6.94	4.61	.02	.67	3.75	1.18	2.61	6.57	371	15.89	21.1	.77	.92
110 other items omitted for lack of space.														
Average of 115 items													.72	.83

Reasonable Economic Performance for Stationary Steam Plants.—The following table, extracted from a lecture prepared last year by Prof. L. P. Breckinridge as part of his fuel conservation work for the U. S. Fuel Administration, indicates the economies that may reasonably be expected in the operation of several types of power and heating plant boilers both for the production of steam and the generation of power.

Type of Plant.	Efficiency of Boiler and Furnace Per Cent.	Coal per Hour, Lb. Per Kw.
Central Stations:		
(a) Large, 10,000 kw. and up	70-76	3-2
(b) Small, 2,000-10,000 kw	68-74	4-2½
Manufacturing power plants:		Per I Hp
(a) Small plants up to 100 hp	60-70	8-5
(b) Medium plants 100-500 hp	68-72	5-3
(c) Large plants 500-2,000 hp.	68-74	4-2½
Heating plants:		Per Boiler Hp
(a) Central, 1,000 hp. and up	68-74	4-3
(b) Office buildings, public bldgs.	50-70	6-3
(c) Residences	50-65	..

Compressed Air Line Connection with Water Main Furnishes Fire Pressure.—The main compressed air line at the shipbuliding plant of the Beaumont Shipbuilding & Dry Dock Co., Beaumont, Tex., which is piped throughout for compressed air, is connected directly with the water line. In the connecting pipe there is a stop valve which normally is closed tight. In case of fire this valve is opened and water under full pressure is available at every point.

Municipalities Adopt City Manager Form of Government.—A number of cities voted at the November elections on the adoption of the city manager form of municipal government. Tallahassee, Fla., by a vote of 225 to 105 ratified a new charter providing for a commission manager form of government. Newport News, Va., gave a majority of 4 to 1 in favor of the new form of government; and Lynchburg, Va., by a vote of 774 to 434 also adopted the city manager type of government.

American Firm May Install Waterworks in 24 Cities of Peru.—The Peruvian government is stated to be negotiating with American interests for the installation of waterworks, drainage and paving in 24 of the largest cities and towns of the republic.

A Page from Recent Waterworks Reports

Frost Penetration in New England in 1917-1918.—The long stretches of extremely cold weather of the winter of 1917-18 caused the frost to penetrate to unusual depths in many sections of New England. J. C. Whitney, Water Commissioner of Newton, Mass., reported that in several instances mains froze at dead ends, the frost in places penetrating to a depth of fully 6 ft.

Geo. W. Batchelder, Water Commissioner of Worcester, Mass., in his annual report for the year ending Nov. 30, 1918, stated that the frost penetrated to a depth of 6½ ft., causing the most severe freezing in the history of the department. A frost penetration of 5 ft. was reported by Edwin T. McDowell, Superintendent of Waterworks of Middletown, Conn.

Grouting Foundations for Dam.—Grout mixed in the proportions of 60 to 1 and applied under pressure of 90 lb. to the square inch was used in closing very small crevices in the ledge underlying the new Pine Hill Dam of Worcester, Mass. The excavations of the site of the dam in places were from 40 to 50 ft. in depth below the original surface of the ground and extended into a ledge. The ledge was found to be shattered to such an extent that it was necessary to remove considerable quantities to obtain suitable hardness to build upon. The numerous seams and crevices allowed the passage of water so readily that it became necessary to drill still further into the rock, and numerous holes were sunk to a depth of 25 or more feet, in order to reach a less porous material. By testing these holes with water under pressure it was found that certain groups were connected through the fissures in the rock, and by traversing the area under treatment it was possible to isolate different groups into convenient clusters for sealing and making water-tight. To accomplish this a short piece of 2-in. iron pipe was connected with each hole, caulked and made fast and tight with a petcock in the top of each, so that the circulation of grout could be controlled. One of the pipes was connected with a grout mixer in which the cement and water were thoroughly mixed under air pressure and forced into the group of holes under treatment. This was done without let-up until the seams refused to take more. In some cases two or three 24-hour days were necessary to effect complete tightness.

War Gardens of Worcester, Mass., Water Department.—About 19 acres of war gardens were cultivated during 1918 by the Water Department of Worcester. The principal crops were beans, potatoes and carrots. Returns from the sale of these vegetables showed a balance.

Firewood Cut from Water Shed.—During the period of fuel shortage in 1917-18 men in the employ of the Water Department of Worcester, Mass., cut several hundreds cords of birch, alders and other woods not desirable on the water sheds. A considerable portion of this wood was burned at the water shop. The balance of the wood was principally sold to the school, fire and police departments. An agreement was made between the mayor and water commissioner, representing the city, and the Worcester fuel committee to permit the cutting of fire wood on the water sheds to relieve the fuel situation. About 3,000 cords were cut under this agreement, for which the city charged the fuel committee at the stumpage rate of $1.75 per cord.

How Middletown, Conn., Handled Frozen Meter Problem.—About 300 meters at Middletown, Conn., were frozen during the severe winter of 1917-18. These were removed, repaired and reinstalled as soon as possible. Protection of meters from frost was neglected by consumers. In many cases the cellars in which the meters were located were much colder than had been anticipated as the scarcity of coal made it necessary for consumers to burn as little fuel as possible. The percentage of frozen meters in Middletown was about the same as in other cities throughout the state. The cost of repairing these frozen meters was small, and the water department, following the example of Hartford, New Britain, Springfield, and other neighboring cities with metered services, held the property owner responsible for the cost. A flat charge of $1.00 was made in all cases of frozen meters and this amount was added to the semi-annual bill rendered in May. For the period which the meters were removed on account of freezing, it was necessary to estimate the charges on the basis of what the consumer used under ordinary circumstances. This, of course, led to more or less dispute on the part of some property owners, but on the whole it worked out quite satisfactorily to both the department and consumers.

Thawing Fire Hydrants with Exhaust from Truck.—During the winter of 1917-18 a number of fire hydrants of Middletown, Conn., froze repeatedly, making it necessary to examine and thaw them daily during the extremely cold weather. The method employed for thawing the hydrants was quite original. The exhaust muffler from a 30-HP. 4-cylinder Federal fire truck was removed and the ends used as companion flanges for fastening a 12-in. piece of 2-in. pipe to the end of the cast iron exhaust pipe. The 12-in. section was connected by a union and elbow to another piece of 2-in. galvanized iron pipe 4 ft. long. To this latter a piece of ⅜-in. hose 7 ft. long was connected by a special coupling. In the thawing operation the end of the hose was forced down the barrel of the hydrant until it came in contact with the ice. The engine was then started and the hot exhaust carried to the frozen parts of the hydrants. Usually they were thawed in 3 or 4 minutes, but in some cases, however, it took 18 minutes. A number of hydrants were broken by the action of the frost and were replaced with new ones.

Borings to Determine Condition of Embankment at Ashokan Reservoir.—During the latter part of the season of 1918 two experimental borings were sunk through the Middle dike of the Ashkohan reservoir of the New York City water supply, for the purpose of investigating the condition of the embankment materials and determining what influence the method of construction had on that condition. Consequently such points were selected as would give a comparison between rolled embankment, puddled fill, and original cover. The borings were made upstream from the core wall at the deepest point of the Beaver Kill gorge. Two and one-half inch casing, except where obstructions necessitated a change to 1⅝-in. casing, was driven or turned down, regular "E" wash-rods and chopping bits being used to loosen the material ahead of the casing. A timber tripod derrick with suspended block was used in conjunction with a gasoline hoisting engine to carry on the work; a 1½-HP. gasoline engine running a Douglas force-pump furnished water to the wash-rods. One boring went through 78 ft. of rolled embankment and 96 ft. of puddle and the other through 77 ft. of rolled embankment and 36 ft. of original cover. The results, according to the last annual report of the Board of Water Supply of New York City, indicated that the rolled embankment was only slightly damp except at one point where a greater degree of moisture was encountered, attributable to a different class of material and coming from the same borrew pit as that used in the puddled fill. The original cover also was in an unscathed condition. The puddled material was in varying degrees of wetness but was confined within the limits of the gorge excavation.

Value of Soap Saved More Than Cost of Water Softening at St. Louis.—The total quantity of dissolved and suspended matter removed from the 37,751,000,000 gal. of river water, which passed through the basins at the Chain of Rocks filtration plant at St. Louis, Mo., during the year ending April 1, 1919, amounted to over 400,000 tons. It required the addition of 1,781 tons of sulphate of iron and 14,999 tons of lime to the river water to precipitate the above quantity of dissolved and suspended solids. The removal of the dissolved solids reduced the hardness of the river water 82 parts per million. This means that the quantiy of soap necessary for every 1,000 gal. of filtered water used for washing purposes would cost 93 ct. less than if the water had not been softened. This saving in the use of soap to the people of St. Louis would amount to a total of over $260,000 for the year, a sum greater than the total annual pay-roll of the supply and purifying section with an average number of 230 employes. The total cost of all chemicals used in water purification during the year added to the cost of all other supplies purchased by the supply and purifying section is some $5,500 less than the value of the soap saved annually through the softening of the water.

The New 10,000,000 Gallon Flat Slab Roof Concrete Reservoir of Dayton, O.

In the year 1917-1918 the Water Department of Dayton, O., built a covered concrete masonry reservoir of 10 million gallons capacity. The population, then estimated at 148,000—which had practically doubled in 20 years and increased by 38 per cent in the last decade—reflected growing war activities. The water consumption was 50 per cent greater than 10 years earlier and the rapidly increasing demand threatened to outstrip the available resources of the department, so that it was necessary to improve the plant, notwithstanding the abnormal prices then prevailing.

Though the average consumption was but 13 million gallons daily, the ordinary maximum daily rate of consumption was upwards of 18 million gallons, and the ordinary maximum hourly rate was equivalent to 30 million gallons daily. The ratio between the maximum and the minimum hourly fluctuations was approximately as 5:1, the minimum rate of consumption being about 6 million gallons per day.

The water supply is derived from a system of driven wells on the banks of the Mad River, in proximity to the industrial center of the city, and is pumped to the consumer under direct pressure, except in the high service district of the northwest, where there is a standpipe of 900,000 gal. capacity.

A description of the methods of design and construction is given in a paper by Leonard Metcalf and William T. Barnes, both of the firm of Metcalf & Eddy, Boston, presented at the recent convention of the New England Water Works Association. The following is an abstract of the paper:

Influence of Topography Upon Character of Water Works Plant.—The topography of Dayton lends itself admirably to the division of the water distribution system into two services—high and low. The low service comprises the congested value district and surrounding business district of the city, at a general elevation of about 740 ft. above sea level. Above, and virtually surrounding the city, lie upland plains, the margins of which are generally between elevations 850 and 900, and which rise with increasing distance from the city, to an elevation of 1,000 ft., more or less. The upland plains furnish advantageous sites for reservoirs close to the heart of the city, from which water may be delivered to the low service district at fair domestic pressure (70 lb. per sq in., more or less) in ample volume for the maximum fire demand, without undue friction loss, and without involving burdensomely expensive pipe connections.

As the first step in the solution of the storage problem it was found more advantageous to locate the equalizing reservoir upon the upland plain. Later, additional reservoirs will be added upon the heights in different sections of the city, feeding their supplies into the common center, the heart of the city.

Factors Influencing Decision as to Capacity of Reservoir.—Under normal conditions the capacity of the proposed reservoir would have been fixed at 25 to 30 million gallons, but in view of the conditions in the building market, induced by the war, it was felt necessary to reduce this limit. The capacity adopted was determined by the amount of storage necessary to equalize the hourly fluctuation in domestic and industrial water consumption, provide storage which would facilitate the making of minor repairs at the Keowee St. pumping station, and meet the "1916 standard" fire supply requirements of the National Board of Fire Underwriters.

The significant rates of demand for water were found to be:

			Rate of Water Consumption				
Year.	Population.	Slip. per cent.	Per capita. Gal. per day.	Average day. M.g.d.	Maximum day. M.g.d.	Maximum week. M.g.d.	Maximum hour. M.g.d.
1911	...120,000	8	73	8.7	....	....	..
1912	...124,000	10	76	9.5	13.0	....	..
1913	...127,000	15	85	10.7	16.5	....	..
1914	...130,000	9	86	11.2	15.1	14.3	25
1915	...132,000	6	75	9.9	12.3	....	..
1916	...145,000	6	84	12.1	18.3	16.5	32*
1917	...152,000	6	86	13.0	17.5	....	..
1918	...160,000	5	38	14.2	20.4	....	..

*Actual.

The maximum rates of demand which had occurred up to 1917 were as follows:

	Ratio to ave. daily for yr. (12.13 M.g.d.).
July 24-30, 1916—Maximum weekly rate = 16.5 M.g.d.	136%
July 24, 1916—Maximum daily rate = 18.3 M.g.d.	156%
July 30, 1916—Maximum hourly rate = 31.9 M.g.d.	263%
July 24-27, 1916—Maximum for four consecutive days = 16.71 M.g.d.	138%

A study of the hourly fluctuation in demand indicated that during the period of heaviest consumption recorded (from July 1 to July 31, 1916) the storage capacity necessary to equalize the hourly demand was approximately 3 million gallons, the maximum and minimum requirements during this period being 3.3 and 1.2 million gallons, the average throughout the month 2.2 million gallons, or approximately 15 per cent of the actual average daily consumption of 14.7 million gallons in the month of maximum demand, July, and 24.8 per cent of the mean daily consumption for the entire year. To maintain a 10-hour flow of the maximum fire demand as prescribed by the 1916 standard of the National Board of Fire Underwriters required an additional storage capacity of approximately 7 million gallons. The sum of these amounts, aggregating 10 million gallons, was therefore adopted as the necessary storage capacity for the new reservoir.

Contract Awarded for Flat Slab Design.—After preliminary studies, designs were prepared for a groined arch type of structure, as on the whole the most desirable and probably the cheapest type for this service, to be built of concrete 264.5 ft. long, 230.5 ft. wide, and 26.5 ft. deep in internal dimensions, and with a 23¼ ft. depth to the flow line.

Although the work was widely advertised and a considerable number of bids were looked for, but three bids were received—all from local contractors—and were opened on July 31, 1917. These bids amounted to $164,592, $188,805, and $192,835, exclusive of the materials to be furnished by the city, which were estimated to aggregate the further sum of $33,500. They were all in excess of the engineer's estimate of $131,000, exclusive of materials to be frunished by the city. When it appeared that these local contractors were not familiar with groined arch construction, whereas they were experienced in the building of flat-slab roof construction, and were therefore ready to submit more advantageous figures upon a structure of the latter type, the bids were all rejected.

New specifications were prepared, permitting the submission of bids upon the engineers' designs and upon designs of the bidder, subject to certain requirements.

The general dimensions were to be the same as in the original design. The principal latitude allowed the bidder was the substitution by him of a flat-slab design based upon formulas and unit stresses given in the specifications.

On Oct. 5, 1917, bids were received and the contract was awarded to the lowest bidder, the Danis-Hunt Construction Co., of Dayton, for $134,832, including materials to be furnished by the city. The design bid upon met the specifications but it involved a radical modification in type of structure from that originally proposed.

The new plans provided for gravity side walls varying in height with the slope of the ground; a groined arch bottom sloping up on its periphery to meet the most economical wall sections; and a flat-slab roof of the two-way system, supported on cylindrical columns 26 in. in diameter and 20 ft. on centers.

The writers are of the opinion that the groined arch type is to be preferred to the flat-slab type for such reservoir structures, on account of greater strength and permanence, but the bids received, under the local conditions then prevailing, were more than enough lower to offset this difference.

Construction Methods.—Excavation was begun by the contractor on Oct. 12, 1917, with Thew steam shovels of the "O" type, with a ⅝ cu. yd. dipper, stripping the surface material and depositing it in storage piles adjacent to the work, by means of two-horse hopper-bottom wagons. Two steam shovels were used—one substantially throughout the job; the other from Nov. 17 to Dec. 6, 1917, although it remained on the work until March 2, 1918. A Keystone excavator was also used during the periods from Nov. 12 to Dec. 1, 1917, and March 1 to 25, 1918. The latter machine was used largely for trimming up the rough excavation made with steam shovel, prior to the final preparation of the foundation by hand. Some of the sand and gravel was handled on short haul by slip scrapers.

By these methods 25,000 cu. yd. of material were handled, 45 per cent of it being delivered to the screening plant located within the lines of the reservoir, for use in concrete aggregate; 30 per cent being stored and subsequently replaced as backfilling, over and against the completed reservoir; and 25 per cent being placed directly in the embankment surrounding the structure.

The surface and subsoil material consisted of a clayey gravel, varying in depth from 1 to 3 ft. Under this was found a clean, sound, and rather fine gravel. To it was added such coarser material as could be obtained at reasonable cost, from a nearby pit and by rail. All of the concrete aggregates, except about 1,800 cu. yd. of this coarser material, came from the site.

After the excavation had been made by steam shovel in the northwesterly corner ot the site, the subgrade was prepared by hand shovel. The 8-in. x 12-in. concrete beams were then laid. Next, alternate floor units were placed—the pier units of the inverted groined arch type, and the marginal units of barrel arch type, extending under the side walls. The concrete in the side walls was then placed in alternate units, one panel (20 ft.) in length, the concrete being poured monolithic from the base of the wall to the roof slab. The alternate floor units previously omitted were then placed, and when a sufficient area of the floor had set, to make working upon it possible, the forms for the columns and the roof were placed. As the slope of the floor of the inverted groined arch units was substantial, the contractor adopted the expedient of setting iron bolts about 2 in. into the concrete to support a wooden sill, upon which was then placed the studding to support the roof forms.

The columns were poured monolithic from the floor to the base of the capital, the capital of the column being poured with the roof slab. The roof was placed in sections covering two or more adjacent lines of piers, joints being broken on the mid-sections between the pier lines.

The effort was made to keep the concrete moist until thoroughly set. The difficulty in accomplishing this upon the roof slab, and the development of undesirable cracks where the concrete dried out too rapidly, has suggested to the writers that it would have been desirable to place a ridge of mortar, 1 in. or thereabouts in depth, around the margins of the completed slabs, in finishing the roof, to form shallow basins in which water might be kept standing until the roof concrete had set thoroughly.

To prevent undue leakage through contraction cracks at the ends of the side wall sections, deep tongues and grooves in the thick section of the wall, and 12 in. by ⅛ in. by 9 ft. 9 in. steel plates through the mid-section of the upper thinner part of the wall were provided.

When the reservoir was first tested the leakage was found to be at the rate of 23 in. vertically, or 864,000 gal. per day. The water was withdrawn and cracks were found along the center lines of the floor invert at certain places. These cracks were cut out and filled with mortar.

The reservoir was refilled on Aug. 15, 1918, and the leakage was found to have been reduced to 2 5/16 in. vertically, or 88,000 gal. per day. Since that time the reservoir has been in active service and the latest observation upon leakage, Nov. 20, 1918, or thereabouts, indicated a loss of 1¼ in. vertically, or 48,000 gal. in 24 hours.

Costs.—The wages paid by the contractor increased progressively from 30 ct. to 38½ ct. per hour for unskilled labor; from 50 ct. to 60½ ct. per hour for carpenters; from 55 ct. to 65 ct. for engine men; and from 60½ ct. to 70 ct. for foremen. Teams were paid 60 ct. per hour.

The total cost to the contractor is estimated at the sum of $85,000 (excluding profit item and materials furnished to contractor by the city): the cost to the city at the sum of $153,041 (including $7,030 for land, $41,805 for materials and $9,341 for engineering and city administration) This results in the following unit costs:

	Contractor's cost (excluding profit) plus cost to city of materials furnished by it to contractor.	Total cost to City of Dayton.	
		Excluding land and engineering.	Including land and engineering.
Gross cost	$126,805.00	$136,670.00	$153,041.00
Cost per cubic yard of concrete (8,746 cu. yd.).	14.50	15.63	17.50
Cost per million gallons of net water capacity.	12,680.00	13,667.00	15,300.00
Cost per square foot of water surface (based upon 60,917 sq. ft. of water of 23.5 ft. average depth)	2.08	2.24	2.51
Cost per acre of net water surface (60,917 sq. ft. or 1.4 acres)	90,600.00	97,700.00	109,300.00

What Meterage Has Done for a New England City

By installing meters the city of Middletown, Conn., has reduced its water consumption from 133 gal. per capita to 78 gal., and as a result the present supply probably will be sufficient for an increase in population from 16,000 to 25,000, which figure, it is estimated, would be reached about 1940. An interesting account of the conditions which led to installing the meters and the results obtained from meterage are given in the fifty-second annual report of the Board of Water Commissioners, from which the matter following is abstracted:

In the winter of 1914 Metcalf & Eddy, Consulting Engineers, made an investigation of Middletown's water supply requirements, particularly with reference to the adequacy of the present supply and to present and future needs of the community, and the steps which should be taken to conserve the present supply or to obtain additional sources if necessary.

In their report it was stated that the combined sources of water supply should be capable of providing at least 2,300,000 gal. per day in dry years. Measurements made at the reservoirs indicated that Middletown was consuming water at the rate of 2,000,000 gal. per day, and attention was called to the fact that the reservoirs had been very nearly exhausted several times in recent years, and that the daily consumption was approaching dangerously near the maximum safe capacity of the supply.

It was the opinon of the engineers that Middletown was consuming much more water than was necessary for legitimate use. A careful study of the growth of the population supplied with water in Middletown revealed the fact that the daily consumption per person supplied had increased from 90 gal. in 1891 to 110 gal. in 1908 and 133 gal. in 1914, and there was every reason to expect that if additional water was supplied the consumption would increase correspondingly, making it necessary to increase Middletown's water supply in the very near future.

Such an increase in consumption could only be attributed to waste and leakage, as it was estimated that the normal consumption should be about 90 gal. per day per person. Unless restrictive measures were adopted there was every reason to expect that preventable waste would continue to increase, and under these circumstances it would be folly to spend money to obtain an additional supply of water merely to allow it to be wasted. It was estimated that it would cost from $60,000 to $85,000 to further develop the Higby supply, and it was felt that the small additional supply secured in this way would not justify the expenditure. It was the opinion of the engineers that the use of meters was the only feasible method of reducing waste of water and establishing an equitable basis upon which to apportion the charges for water.

Taking into consideration this opinion of experts and considering also the main points in the case, namely, supply, waste and expense, the Board of Water Commissioners were confirmed in their honest belief that for the best interests of Middletown water meters should be installed without delay. They accordingly took active steps to that end under the authority of the Common Council, and immediately brought upon themselves the severest criticism. They persevered in the work, however, although by so doing they incurred much odium and were roundly abused. But experience now shows that their course was fully justified. There has been an enormous reduction in the consumption and the almost total absence of complaints about water bills during the November collection indicates that the people are satisfied with the present system

Unfortunately the Venturi meter at Higby reservoir was not installed until the work of setting meters had been commenced and a considerable portion of the city had been metered before an accurate knowledge of the daily water consumption was available. The daily consumption before meters were installed was 2,000,000 gal. By the time the Venturi meter was put in operation in June, 1916, the daily consumption had decreased to about 1.7 million gallons. The figures given in the table below, which were computed from the readings of the Venturi meter, show how the daily consumption has decreased as the work of setting meters progressed.

AVERAGE DAILY CONSUMPTION IN MILLIONS OF GALLONS.

	1916.	1917.
January	.....	1.449
February	.....	1.535
March	.....	1.492
April	.....	1.414
May	....	1.357
June	....	1.226
July	1.614	1.143
August	1.676	1.475
September	1.619	1.240
October	1.688	1.230
November	1.602	1.195
December	1.556	1.335

As stated above, the daily consumption in 1914 was 2,000,000 gal. With an estimated population of 15,000 persons supplied with water the daily consumption amounted to 133 gal. per person. It is estimated that the present population supplied is 16,000, and as the present average daily consumption is about 1.25 million gallons, the consumption per person is about 78 gal. per day. At this rate of consumption the present sources of supply would be sufficient for a population of over 25,000, and from a study of statistics of other cities of the same size and character of Middletown it is estimated that the population supplied with water will not reach this figure until about the year 1940.

It was not the purpose of the meters to compel consumers to stint themselves in the use of water, but to compel the careless consumers to stop avoidable waste and leakage. The discovery and stoppage of hundreds of leaks by the consumers in co-operation with the Water Department has shown that the metering of the services has had the desired effect. The meter rates allow for an ample use of water for all legitimate purposes without incurring undue expense. It is the opinion of the Water Department that very few people are using less water than formerly, but the great reduction in the daily consumption has proved without a doubt that a large portion of the water was formerly deliberately wasted by careless use or lack of attention to defective plumbing.

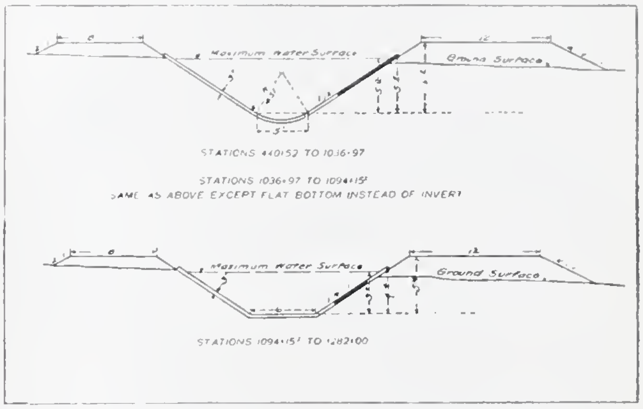
Statistics of the November collections from metered services within the city show that 18 per cent of the consumers were paying more than on the flat rate basis, 80 per cent were paying less and 2 per cent were paying the same as before. The yearly receipts amounted to $50,090. This is the second largest annual collection in the history of the department, and in view of the fact that such a large percentage of consumers are paying less for water than formerly the enormous saving to the general public is at once apparent.

About 25 per cent of the consumers are now paying the minimum charge of $2.50 per semi-annual period, while on the flat rate basis only 1¼ per cent paid the minimum charge. It had not been anticipated that the number who would pay the minimum charge would be so large, but it is thought that a few of these consumers misunderstood the purpose of the meter system and perhaps used less water than was convenient owing to a fear that the charge would be unreasonably high. These consumers used a very small amount of water, and as many of them had a number of fixtures on their premisee which were really used very little but for which they formerly paid a large rental, it is apparent that the old method of apportioning charges for water was quite unfair. It is thought that as the purpose of the meters becomes better understood the number of consumers paying the minimum charge will decrease somewhat with a consequent increase of revenue to the city.

Panama Canal Revenue in Excess of Expenses.—During the fiscal year ending June 30, 1919, the ordinary expenses for the operation and maintenance of the Panama Canal, including those of civil government and sanitation, amounted to $6,112,194. Overhead charges included in this total amounted to $3,382,167. Offsetting the total expenses for operation and maintenance are the amounts earned for tolls on vessels passing through the canal, $6,156,118; licenses and taxes, court fees, and fines, $136,870; and profits on business operations, $61,027, a total of $6,354,016. The revenues earned in excess of current expenses were accordingly $241,822. The charges for operation and maintenance, however, do not include, with minor exceptions, any allowance for depreciation of plant and equipment, nor do they include any interest charges on the capital investment. The actual cost of the canal projects estimated for in 1908 up to June 30, 1919, is figured at $365,415,985, which may be considered as the capital investment on that date.

Removal of Sand from Irrigation Canal by Sluicing

Sluicing operations have been successfully used in removing sand from the west extension main canal of the Umatilla Project of the U. S. Reclamation Service. This canal, built during the years 1914 and 1915 and operated since 1916, is 26¾ miles long, concrete lined throughout, and has a designed capacity of 365 second feet at the head, 212 second feet from station 441 to 1094, 132 second-feet from station 1094 to 1282, and 77.5 second-feet from station 1282 to the end. It is built through some very sandy areas, and the high winds prevailing in the spring have blown much of the excavated material into the canal. The spring of 1918 was very windy and much sand was blown into the canal. The first 7 miles and the last 5 miles of the canal were comparatively free from sand deposits, but the intervening 12 miles contained an amount estimated at from 50,000 to 75,000 cu. yd. It was suggested that sluiceways be built at intervals of several miles and an effort made to remove the sand by the aid of water. This it was thought would be more economical than any method of moving it, by teams or machine (as had been done in 1916 and 1917) out on the banks where it could readily be blown in again. An interesting description of the sluicing operations is given by Mr. H. M. Schilling, Project Manager, in the September Reclamation Record, from which the matter following is abstracted.


Maximum Water Surface
Ground Surface
STATIONS 440+52 TO 1036+97
STATIONS 1036+97 TO 1094+15¹
SAME AS ABOVE EXCEPT FLAT BOTTOM INSTEAD OF INVERT
Maximum Water Surface
Ground Surface
STATIONS 1094+15¹ TO 1282+00

Sections of Umatilla West Extension Canal.

By the middle of July two structures had been completed, and on July 15 one was operated for 26 hours. The immediate result was the movement of sand for a distance of ⅓ mile. After that the sand took a grade of about 4 ft. to 1,000 ft. and, with 30 second-feet of water, which was all the water available, no further action was effected. Similar movement resulted at the other sluiceway.

During August two additional sluiceways were built and operated intermittently. It then developed that the serious problem was that of loosening and transporting the sand. Various methods were tried. A drag attached to a cable leading to a team on either bank was used, but it made no impression. A farm plow was effective but was so heavy that it required two 4-horse teams and was given up as too expensive. Two iron sheaves, about 16 in. in diameter, attached to a chain, had the desired loosening effect, and could be pulled by two 2-horse teams, but the problem of transportation still remained. The sand was too heavy to remain in suspension and after being loosened, it would settle again.

Throughout the month of September operations were continued with no appreciable results. On the 26th, after studying operations above No. 2, where the sand was filled with a growth of moss roots, it was decided to construct a gate or template to loosen the material. The first experiment was made with a gate 4 by 6 ft. in dimensions attached to a 4 by 6-in. timber which spanned the canal. The gate was placed inclining upstream and the water pressure held its lower edge down on the sand. This created higher velocities around the gate and dislodged the sand. It then settled gradually and eventually would wash completely under. It was then moved about 20 or 25 ft. upstream and pulled over the 4 by 6 timber by means of a rope and the water repeated the operation. Where the sand deposits were not excessively heavy fair progress was made in loosening the sand. Observations on this gate suggested making a larger one with several holes at the bottom. It was an improvement and led to the development of the present template, which consists of a wooden diaphragm about 6 in. smaller than the section of the canal, with an opening 2 ft. wide, running vertically from bottom to top. This permits the increased water velocities to concentrate through the middle directly on the sand, as well as on the sides and bottom. Instead of attempting to work upstream the progress was reversed and as the water washed the sand out ahead of the gate the template was moved downstream a few feet. The water pressure assisted materially in moving the gate so that one man could easily operate it by crossing back and forth on the 4 by 6 timber and regulating the movement. In this way the problem of transporting the sand with a comparatively small head of water was solved.

The last type of template was first used above No. 3 sluiceway in October and proved a success. By the latter part of the month everything was made ready for a program of sluicing. The flumes at No. 1 and No. 3 were extended and lowered so as to do away with the big drop caused by the water in leaving the sluiceways. Two shifts on the gates were arranged and several gates were in operation at the same time; being kept about 4,000 ft. apart. The larger bars were moved in sections, about 700 to 1,000 ft. proving to be the most economical load. In this manner sand was transported above No. 1 sluiceway, a distance of 14,300 ft., or nearly 3 miles. Under ordinary conditions a gate would progress about 600 to 1,000 ft. per 8-hour shift, depending on the density of the sand deposit. Sometimes several trips were necessary to get the sand out to the desired depth After the major portion of the sand had been gone over above No. 1 sluiceway, and the head increased to about 75 second-feet, the water was divided at No. 1 and about half passed on to No. 2. This enabled operations to be carried on at two sluiceways at the same time.

As the irrigation season closed the last of October, sluicing operations were unhampered during the winter months and steady progress was maintained. No. 5 sluiceway had been built in November, 1918, but was not put in operation until March, 1919. By May 1, 1919, 38,981 cu. yd. of sand had been sluiced from the canal. About 21,000 cu. yd. yet remain, but it may be stated that the canal has been successfully cleaned with the exception of about 11,000 cu. yd. of sand in the vicinity of Juniper Canyon. It was the intention to remove this in the fall of 1919 by bunching the material with the templates and removing with teams in order to avoid the long transportation to sluiceway No. 5.

Records of team costs show that under favorable conditions the upper portion of the sand bars could be removed for 27 ct. per cubic yard. Under less favorable conditions the cost amounted to 40 ct. per cubic yard. Teams were very difficult to secure and the fresno work could not be done successfully below a depth of 5 ft. on the slope. To have gone deeper it would have been necessary to use slips, and the cost would have been increased greatly.

Complete cost records to May 1, 1919, on the sluicing method of sand removal show that the field cost was $0.158 per cubic yard. With the addition of $0.059 per cubic yard for engineering superintendence and all overhead charges, and $0.04 per cubic yard as a plant charge for building sluiceways, the total unit cost is $0.257.

Considerable work has been done in replacing embankment and covering it with brush for protection against winds. Sand fences of brush were placed at right angles to the center line of the canal where some of the worst blows occurred. Certain portions of the banks were sown to rye but not sufficient moisture fell to start it. Weeds and grass are very scarce as the dry, loose sand is not conducive to vegetation. Conditions are improving, however, and once the canal has been cleared of sand deposits it is expected that it can be kept clean by the protective bank work and by running heads of water to the limit of the canal capacity.

Measuring Park Water by Meter Wheelbarrow.—A unique arrangement for metering the water used for sprinkling and other purposes is employed at the city parks of San Diego, Cal. The meter is fastened on a wheelbarrow, and when in use is connected to the hydrant or faucet by a short piece of hose.

California Regulations for Construction and Operation of Swimming Pools

The Bureau of Sanitary Engineering of the State Board of Health of California has recently adopted regulations governing the construction and operation of public swimming pools. The rules are for the express guidance of designers, owners, managers and operators of such public pools in the state of California. Certain suggestions as to the suitable means of obtaining desired results are given. The following comprise the essential features:

All the water in the pool and applied to the pool shall be continuously safe hygienically. As a tentative standard a total bacterial count of 1,000 colonies per cubic centimeter on agar incubated at 37.50 C. and a B. Coli count of 1 per cubic centimeter is set for the pool water in any part of the pool, examined within 48 hours after sampling. All tests are to be made in accordance with the latest methods of the American Public Health Association.

All the water in the pool shall be continuously clean, and clear enough that bathers may be distinctly seen on the bottom of all parts of the pool. It shall be free of noticeable suspended or floating objects or particles, scum or sputum.

The pool walls shall be vertical, and walls, floors and surrounding walks shall be surfaced with white tile, cement (white or gray) or other impervious material, with as smooth a surface as each use permits, for easy cleansing. The swimming pool floors shall not slope more than 1 ft. in 20 ft. where the depth of water is less than 6 ft. Depth opposite diving stands and spring boards shall be at least 8 ft. 6 in.

The entire pool shall be surrounded by a raised concrete curb at least 2 in. high by 12 in. wide, serving as a clean space on which bathers may sit and as a check against walk drainage flushing into the pool. Walks may slope toward or away from the curb to a grating-covered drain channel, or drain outlets in the walk. Walks shall be at least 4 ft. wide in the clear. They shall slope at least ½ in. per foot toward the drains. All corners shall be rounded for ease in cleaning.

An arrangement of inlets and outlets giving the maximum uniformity of displacement of "used" by "incoming" water, and the maximum avoidance of short circuits or "dead" areas shall be used. Where a type of inlet consisting of a series of inlets scattered along one side of the pool not more than 10 ft. apart, and outlet similarly scattered on the opposite side, are not used, it must be with the specific approval of the State Board of Health.

A scum gutter on all four sides of the pool, recessed into the side wall and designed to prevent bathers from having easy access with fingers, hands, arms, feet or bodies, shall be provided. Drainage facilities from such gutters shall be of such size and spacing that all overflows and splash shall be promptly carried away into a sewer and not returned to the pool or circulating system. Gutters or drains along the top or side of the wall, open and accessible to bathers, will not be permitted.

Gutter drainage, wash water from filter and emptyings from the pool shall be considered as sewage water and shall be disposed of accordingly.

Sand beaches, earth walks, board walks, lawns and the like, which may contribute contamination or objectionable filth to the pool or its premises, shall not be permitted.

Spectators and persons not dressed for bathing shall not be allowed on the walks used by bathers, and bathers who leave the premises and return with suits or bodies soiled by sand, earth or objectionable contamination shall not be permitted to re-enter the pool while in this condition.

Plunge rooms, dressing rooms, shower rooms, toilet rooms, lavatories, hallways, etc., shall be commodious, well lighted, well ventilated and clean. Floors for dressing rooms, hallways, toilet rooms, lavatories and showers shall be of tile, concrete or other impervious material, sloping at least ½ in. per foot to nearby grating-covered drain channels or floor drains, except that floors for dressing rooms and hallways may be of wood, provided they be treated to keep them impervious and clean.

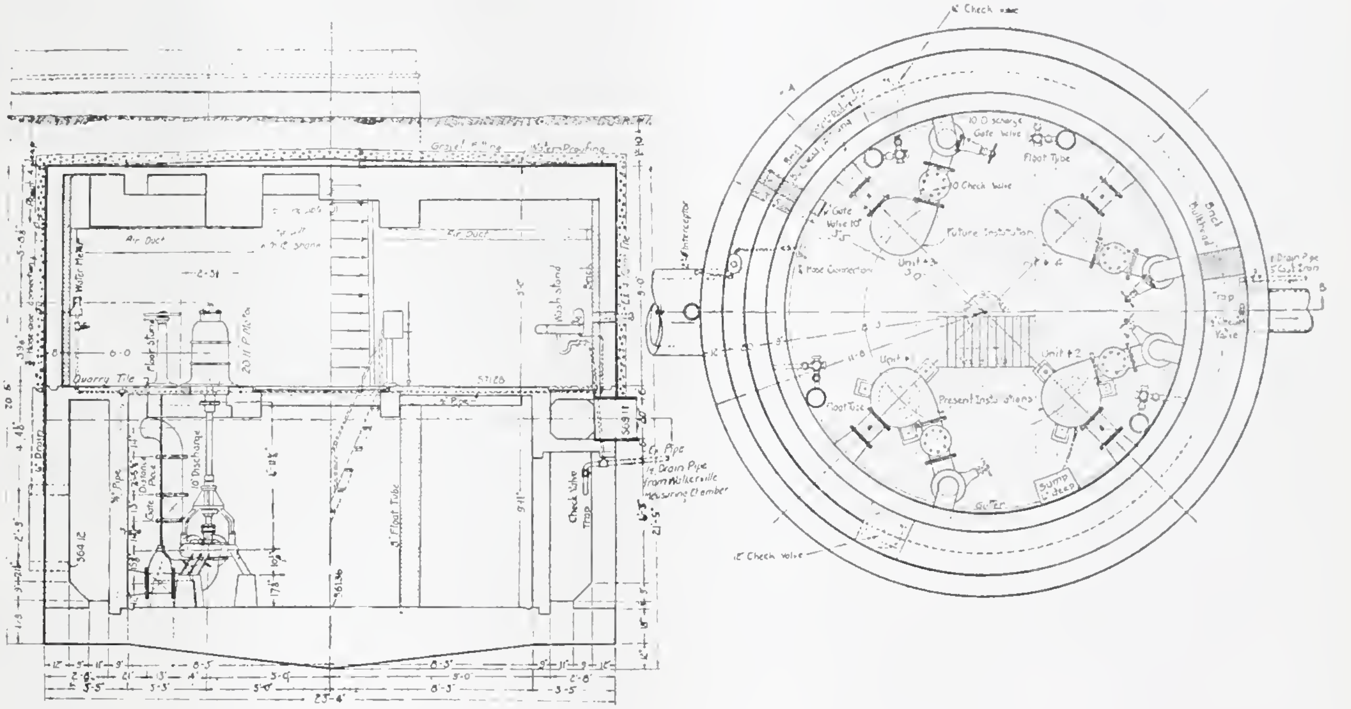
There shall be at least one shower head, provided with soap, for each 30 dressing rooms. Shower rooms shall be easily located from every dressing room.

There shall be at least one toilet room for each 30 women's or children's dressing rooms and at least one toilet room for each 60 men's dressing rooms. There shall also be urinal spaces to accommodate at least 5 per cent of the capacity of men's dressing room Urinals shall be of a type which will prevent splash of urine upon the floor or feet of bathers, and floors opposite shall be free of any evidence of foulness. Toilets and urinal rooms shall be located for ease in finding from every dressing room and from the pool, and shall be distinctly marked. Outdoor toilets shall be screened against flies and constructed according to good sanitary practice.

Where sanitary drinking fountains are provided they shall be of an approved type.

Equipment shall be provided for the rescuing and reviving of drowning persons, including life buoys, life hooks and rope.

At least one attendant or life guard shall be on duty at pools to which admission is charged at all times when in use, who shall be familiar with the rescuing and reviving of persons apparently drowned.



Section Through Pump and Motor Rooms and Plan of Pump Room.

Bathing suits and towels shall be thoroughly cleaned and sterilized after each use.

The general appearance of all the premises shall be one of cleanliness, airiness and sanitation. All surfaces possible shall be painted with light colored paint.

The management shall keep on file a record of daily attendance and operations as prescribed in each individual instance, which shall be submitted to the Bureau of Sanitary Engineering on demand.

The management shall keep posted conspicuously in its office and in all dressing rooms such regulations governing the conduct of bathers as may be issued from time to time by the State Board of Health, and shall enforce the same strictly.

It shall also keep posted conspicuously near its office or entrance to the pool a report of the latest bacteriological analysis of the water in the pool, as furnished by the Bureau of Sanitary Engineering. False and misleading claims relating to any sanitary condition or feature about the pool or premises shall not be displayed.

Sewerage for Jerusalem.—A sewer system is in course of construction in Jerusalem which will provide the Jewish quarter with adequate sanitary facilities. It has been undertaken by the Zionist Administrative Commission, and most of the preliminary surveys were made by Jewish engineers and the actual construction is being carried out by Jews. The disposal plant is to be so located that Christian and Moslem communities will be able to derive full benefit. The scheme involves an expenditure of about $50,000.

Underground Sewage Pumping Plant

A circular sewage pumping station entirely underground is being constructed at Walkerville, Ont., to take care of the sewage from a low-level interceptor and lift it enough to flow by gravity through a treatment plant. A description of the plant appears in a recent issue of the Canadian Engineer and the principal features of it are given below.

The pumping station is a circular, 2-story, reinforced concrete structure, 23 ft 1 in. in diameter and 20 ft. 5 in. high, all built below ground with the exception of the superstructure which houses a stairway leading to the floors below somewhat on the style of a subway entrance. The upper compartment contains the electric motors, while the lower compartment contains the vertical pumps and is entirely encircled by an annular suction well, above which is the force main. The circular design for the station was chosen, after a careful study of all the factors, because it gave a very efficient and compact arrangement for the pumping units, and allowed a very considerable saving of reinforcing steel and concrete.

The pumping equipment will consist of four units, two of which will be installed at present. The other two will be added when required. Each unit consists of a 20-HP. vertical motor and a 2,000-gal. vertical centrifugal sewage pump. The units will be automatic in operation.

The lower compartment, containing the pumps, is encircled by two compartments, from one of which the pumps draw their suction, discharging into the other, which is connected by a force main to the gravity sewer at a higher level.

The upper compartment, or motor room, will eventually contain four vertical motors, four float switches, the switchboard, wash-stand, lockers for supplies, etc., and a venturi meter register. The sewage will be measured by a venturi tube situated in a chamber on the force main about 50 ft. from the pumping station, the pressure pipes being led back to the register in the motor room.

Electric power will be used, and to provide for interruptions in current flow, 12-in. check valves are placed between the suction and discharge chambers, so that should the sewage rise to a sufficient height in the suction well, it would flow through the check valves and on into the force main with the minimum damage, if any, by flooding the interceptor and overflowing into the river.

A system of ventilation will be installed, capable of supplying 500 cu. ft. of air per minute, or a complete change of air in 10 minutes.

The pumping station is being constructed by the R. Westcott Co., Ltd., contractors, of Windsor, Ont., who are doing the excavation and concrete work at actual cost plus 15 per cent, and the installation of pumping units and other equipment at a bid price. The total estimated cost, including two pumping units and engineering and contingencies, is $18,900.

The station was designed by Willard R. Rhoads. The firm of Morris Knowles, Ltd., is the engineer for the Essex Border Utilities Commission.

Experiments to Adapt Cobwell Process to Handling Sewage Sludge

A number of small scale and several large scale experiments have been undertaken to determine if the Cobwell process, heretofore applied particularly to handling of garbage, dead animals, slaughter house offal and other wet organic waste materials, could be adapted to the disposal of sewage sludge with by-product recovery. The results of these experiments, according to a paper by Raymond Wells, Consulting Chemist, Homer, N. Y., presented Nov. 12 at the twenty-fifth convention of the American Society for Municipal Improvement, seem to warrant some hope of solution of the problem. The matter following is abstracted from Mr. Wells' paper:

It is unnecessary to go into any detail in description of the Cobwell process. But some variations are required in applying it to handling of sewage sludge.

In this method of dehydration with simultaneous degreasing the principle employed is that of desiccation in a hot bath of an immiscible solvent, which shall serve not only as a dedydrating medium but shall also during the period of drying continually dissolve the grease contained in the material to be dried. Such a solvent preferably employed in the handling of sewage sludge is a high-boiling petroleum naphtha, distilling within the range of 360-420° F., which corresponds to the first 60-70 per cent over in the fractionation of "Standard Water-white Kerosene." This material serves not only as the most economical heating medium, but, owing to the high temperature maintained in the desiccating mass, serves to remove or dissolve the metallic soaps as well as the free grease. Cold or merely warm solvents of a less oily nature have little solvent action on such soaps, but high boiling oils, particularly when carrying small quantities of grease, are able to dissolve them without difficulty. Upon cooling they are apt to be deposited as jelly-like masses or to cause the gelatinization of the whole solvent solution, and for that reason the solution must be treated before entering recovery stills, in such a manner that the soaps are decomposed and a solution of clean fatty acids results. This treatment will be taken up in order.

The following is a brief description of apparatus and method of carrying out operation:

The principal apparatus consists essentially of a closed tank, circular in shape and of a diameter three times the height. Jackets are provided on the bottom and well up the sides, so that as much available heating surface is obtained as is possible. Through the bottom, oblong screened openings are provided for the withdrawal of solvent and grease and for the pumping in of solvent during the cooking or dessicating operation. Within the tank proper is a central shaft, provided with two sweeps set very close to the bottom, in such a manner that they shall slide under the mass to be treated, imparting an undulatory motion, without cutting through the mass itself. For this reason very little power is required. The tanks are of shallow form in order that the amount of heating surface in proportion to the mass to be treated may be as great as possible. Greater height and capacity could only be obtained at the expense of operating time and greater consumption of power. The top of the tank is provided with charging manhole and outlet pipe for vapors to condenser.

After the tank is loaded with sludge, the charging manhole is securely closed by the swing cover, solvent is admitted through the bottom screens, sufficient to totally immerse the mass of sludge and steam turned on jackets. Combined vapors of solvent and water vapor pass out through vapor line to surface condensers of suitable capacity, and in these the mixture of solvent and water vapor is condensed to liquid, which leaving the tail pipe of the condenser, and passes to separating tank, where by virtue of the lighter gravity of the solvent, separation of solvent and water is effected. The solvent flows to storage for reuse. Owing to rapid evaporation, the solvent level is lowered in the tank and a further quantity is pumped in.

Four to five hours are required for the evaporation of all of the water and at this time through the sight glasses the dried fiber, etc., can be observed floating on the top of the solvent. At this point the agitator is stopped, the steam turned off and the drain valves opened and the grease-laden solvent pumped out through a solvent out-pump line. Several washes with fresh solvent complete the degreasing of the mass, which is then heated, agitated and with the help of live steam, freed from the absorbed solvent, left in mass after draining.

The solvent, carrying with it the extracted grease, soaps, etc., must receive preliminary treatment before passing to the solvent-recovery and grease-finishing stills. This treatment is carried out in a leadlined tank provided with agitator. To the solvent is added a sufficient quantity of sulphuric or muriatic acid and water to completely decompose the metallic soaps present. The acid water is well churned up with the solvent, allowed to settle and drained off, fresh water is added and mixed, allowed to settle, and the clear grease solvent solution run to the recovery stills. By this treatment, foaming and other difficulties are avoided in the distillation and the grease recovered does not form the difficulty separated emulsions it is disposed to do. Such grease can be cleaned up and settled free from mechanical impurities and moisture without undue trouble.

The entire cycle of operations takes place in a closed circuit and the only vent for non-condensible gases for the whole system of tanks (or reducers), condensers, separating tanks, washers, stills and storage tanks, is on the final solvent storage tank or tanks. This vent in turn exhausts through an oil scrubber to recover traces of naphtha carried over by carburetting. During no period of the operation is the sludge exposed to the air or manhandled in any way, until it is finally discharged from the side door of the tank in a dried degreased condition. The only places where odors or noxious effluent are exposed to the air and liable to cause an insanitary and nuisance condition, is first at the gas vents on the storage tanks and at the effluent overflow on the separating tank. This effluent is of course distilled water from the sludge and carries with it the odor of the sludge, which in the case of fresh sludge and that preferably handled, is very offensive. The quantity of this water is of course equal to that contained in the sludge prior to dessication and the condensed steam from the steaming out of the solvent from the drained sludge, prior to dumping from machine. This approximates a ton of effluent for every ton of sludge handled. The only way found by the writer to effect deodorization of this effluent and of rendering it harmless, is by the addition of chlorinated lime or chlorine water. The greatest amount necessary for deodorizing very foul water is one part of 35 per cent available chlorine bleaching powder to 3,000 parts effluent. The non-condensible gases leaving the storage-tank vents, must be scrubbed with chlorinated lime solution before allowed to pass to atmosphere.

With these precautions it is safe to say that the entire operation of dessication and degreasing, or the whole recovery operation, can be carried out with no offense to public welfare and sanitation.

In handling sewage sludge by this method, no difficulties have arisen, other than those usually met with in handling wet organic materials of other sorts, and since in sludge the moisture is present in free condition, mechanically combined, the period required for dessication is much shorter than that met with in the treatment of garbage and animal refuse, in which the majority of the water is more or less chemically combined. For this reason only four or five hours are required in drying a given amount of sludge, compared with at least twice that for the same amount of garbage.

Experiments and trial runs indicate the capacity of each tank as 8 tons in 24 hours and in a plant handling the sludge from a town of 200,000 inhabitants (approximately 40 tons) 75 per cent moisture basis daily, the cost for handling, including overhead and fixed charges, will approach $6 to $6.50 per ton on green sludge. This cost will not be greatly changed in handling sludge containing 75 per cent or 50 per cent moisture, but since the gross tonnage to be handled would be greatly reduced, the plant investment would be greatly reduced and the by-product returns per green ton much greater. If by any method of dewatering on beds or other inexpensive method, the moisture can be reduced below 75 per cent, by just so much will the success of a recovery plant pass from just self-maintenance to a possible profit.

Suggestions for Reducing Waste of Irrigation Water

In the early days of irrigation in any country, the chief interest and energy are exerted in developing the water supply. But when the water supplies are fully developed, farmers and others interested in agriculture must study the efficiency of irrigation in order that the waste of water may be reduced and the supply made to serve as large an acreage as possible. In some communities the various losses of irrigation water aggregate as high as 80 per cent of the total quantity diverted from the stream. Beginning at the point of diversion the supply stream suffers continuous losses. The sequence of these losses is as follows: Seepage (and evaporation) from canals; seepage from the field laterals, evaporation upward from the irrigated fields; seepage downward from the fields and willful or careless waste. An interesting discussion of these losses, together with suggestions for their reduction, are given by Mr. G. E. P. Smith, Irrigation Engineer of the Agricultural Experiment Station at the University of Arizona, in a bulletin issued recently by the station. The matter following is abstracted from the bulletin:

Losses from Canals and Field Laterals.—Measurements of seepage losses on scores of ditches and canals in the Western states have been compiled and published. The results are startling. Losses of over 10 per cent per mile are not infrequent, and it is concluded that "a large percentage of the water, estimated at 40 per cent of the amount taken in at the heads of the main canals, is lost by absorption and percolation along the routes." The records of the U. S. Reclamation Service in the Salt River Valley state that during the past six years the canal losses between the Granite Reef and Joint Head diversion dams and the points where water is delivered to the water users have been from 40 to 45 per cent of the total amount diverted. While the losses as given in the records may be overstated somewhat, it is certain that at least one-third of the water diverted is lost in the canals. The loss from the Avondale Canal is 40 per cent in the first four miles.

Practically all of the loss in canals is by seepage, for the loss by evaporation is small. The evaporation from a free water surface during the summer months at Tucson, Ariz., averages 10 in. per month in depth. On that basis a canal with a water surface 10 ft. wide and carrying 25 second-feet of water would lose just one acre-foot per month per mile by evaporation while the total discharge in the same time would be 1,500 acre-feet.

An excessive seepage loss can be reduced somewhat by puddling the canal with clay. This method, however, is not recommended for general practice, for it is a temporary half-way measure, and the puddling must be repeatedly injured by ditch cleaning. Oil lining has been tried to some extent in California and is said to reduce the seepage about 50 per cent, but it does not prevent the growth of weeds and ditch cleaning becomes more difficult. The best method is to line the canal with concrete, or, in the case of small ditches, as from pumping plants, to convey the water in cement pipe lines. Concrete linings are coming into use widely, and they will be employed more extensively as projects become thickly settled and the value of the water increases. The Tucson Farms Co. has lined 2½ miles of its canals with 3-in. reinforced concrete. The cost of this lining was about $18,000, while the value of the water saved is at least $40,000. The Agricultural Products Corporation has used cement pipe lines throughout for its distribution system, 26 miles in all. The Southwest Cotton Co. uses both canal linings and cement pipe lines and ultimately will carry all irrigation water in concrete. Concrete linings and pipe lines have additional advantages: ditch cleaning is nearly or quite eliminated; breaks, especially those caused by the gopher holes, cannot occur; and the labor cost of irrigating is reduced.

Evaporation from Irrigated Fields.—The direct evaporation of water from the ground surface may account for from 10 to 40 per cent of the water applied. This loss is much larger on heavy loams and adobe soil than on sandy soil. It is greatest, of course, during and just after each irrigation and decreases gradually until the next irrigation. In the case of alfalfa it is comparatively high after each cutting and decreases as the plants grow again and shade the ground. It is greater on an open wind-swept area than on one protected by windbreaks.

Many methods for reducing the evaporation loss are available to the farmer. They are:

Deep plowing. A shallow seed bed underlain by packed soil tends to cause a high evaporation loss. From 7 to 9 in of soil should be turned over by the plow.

Cultivation In the case of crops planted in rows, such as corn, the ground between the rows should be cultivated as soon as possible after each irrigation. In the case of orchards, the ground should be furrowed just before irrigating and cultivated just afterward If the furrows are 6 in. in depth, one may expect to save 60 per cent or more of the loss which would occur without the mulch. Even alfalfa needs cultivation at least twice a year, and particularly after the soil has been packed by winter pasturing.

Increase in soil fertility. It is difficult to make a mulch when humus is lacking. A fertile soil takes water readily and, if cultivated, retains it with comparatively little loss by evaporation. Straw should be spread on the ground and plowed in. Weeds, trash, and perhaps a green manure crop can be utilized to improve the fertility. All stable manure should be spread and plowed into the soil.

More thorough and less frequent irrigation. This practice, besides saving water, tends to establish deep root feeding, while frequent light irrigations encourage shallow roots. For alfalfa one irrigation per cuttting is ample except for sandy soils, where two lighter irrigations are preferable.

Irrigation at the right time. Irrigate heavily before planting, and withhold water after the planting for a considerable time. In the case of alfalfa, irrigate about a week before cutting. This will supply the water when it is most demanded for plant growth, and after cutting, the ground being still moist, the new crop will spring up quickly and shade the ground. Wheat should be planted in thoroughly irrigated ground, and, with the aid of good winter rains, no irrigation is needed until the boot or flower stage. Cotton should be irrigated sparingly in the early stages of growth.

Irrigation at night. Evaporation is much restricted in the night compared with the day time. It is a great mistake to shut down pumping plants each evening.

Elimination of weeds. The waste of water to raise weeds should be included with evaporation losses. Weed farming is unprofitable.

Windbreaks. They should be planted along the ditch banks and the road sides. Every farmer should raise his own fence posts and fire wood. Wind movement in the Salt River Valley is greatly reduced by the long rows of magnificent cottonwoods with which the landscape is checkered. The nearby fringes of fields require additional fertilization, but the net result of the windbreaks is beneficial.

Seepage Loss from Irrigated Fields.—As a rule, this loss is even greater than the preceding one. It is particularly severe on light soils. It could be avoided to a large extent if no more water were applied at each irrigation than the amount that can be held by the soil within reach of the plant roots.

An ideal irrigation consists in applying the right amount of water, evenly distributed over the field. Throughout the central and southern portion of Arizona the practice for field crops is to lay out the field in long strips or "lands." In many observed cases the water, turned in at one end, requires from one to three hours to traverse a land to its lower end. As soon as the water reaches the lower end the ditch water is turned to another land. For one or two hours, then, the head end of a land gets water, part of which soaks downward beyond the reach of, and beyond the need of, the plant roots, while at the far end the land receives water for 15 to 40 minutes. Surely, this is not an ideal irrigation. In 1913 the author made several tests of the evenness of distribution of the water. In one case, on heavy loam, it was found that the percentage of soil moisture at the head of a land, for 6 ft. depth, was increased from 24.1 to 26.3 per cent by a 4-in. average irrigation, while at the tail end the soil moisture was increased from 15.4 to 18.2 per cent. In another case on sandy loam the soil moisture at the head end was increased from 14.3 to 21.1 per cent and at the tail end from 8.3 to 12.2 per cent. In both cases, therefore, the head end had more soil moisture before irrigating than the tail end had after irrigating—a preposterous condition. Inasmuch as the alfalfa near the foot of each land was making excellent growth it follows that the head ends of the land were getting unnecessarily large, wasteful amounts of water. On one of the fields thus tested the average depth of water applied in 1914 was 108.2 in. Unquestionably, 50 per cent of the water thus applied sank to the water table and was wasted. Many similar cases have been observed in alfalfa irrigation and in furrow orchard irrigation, where the quantity of water absorbed at the head ends of the furrows was found to be excessive and wasteful. When these conditions exist, the remedy is less water more rapidly applied, by means of a larger head, or shorter runs, or steeper slopes.

Although in general the head ends of the fields are given too much water, yet there are exceptions to this rule. Thus, on clay loam and heavy adobe soils, if the lands have considerable fall, the irrigating water runs quickly to the lower ends of the lands without soaking into the ground more than a few inches. A similar effect is produced by very silty water, such as that of the Gila and Colorado rivers; a silt-blanket is formed at the upper end of the lands and becomes almost impervious. In such cases the remedy is either to divide the head of water over more lands, or to use a flatter gradient, and silt-blankets must be broken up and mulched.

The frequently discussed problems of what slope to give the lands and what head of water is best are interrelated, and involve also a discussion of the length and width of lands, and the character of the soil. Any one of these five factors can be taken as a function of the other four factors. The problem is complex and should be solved separately for each crop and for each locality. In some communities the lands are graded level or on a very slight gradient at an additional expense of $20 to $40 per acre. This outlay is of doubtful utility. The lands should be graded down the natural slope or approximately so. Surely any lands with slope from 3 to 40 ft. per mile can be laid out and irrigated without material change in the general direction of the slope. The other factors, then, can be determined so as to give the most uniform distribution of water. Thus, on light soil with a grade of 20 ft. per mile, where a large head of water is available, perhaps the lands can be laid out 50 ft. wide and 880 ft. long. If the head of water is small, as from a No. 5 centrifugal pump, then the lands should be not over 30 ft. wide and 440 ft. long. If, however, the grade is only 10 ft. per mile, the lands, perhaps, should be 660 ft. long for the large head and 330 ft. long for the small head. These values are intended to be suggestive; on shallow soils underlain by caliche the lands can be longer; in some cases lands 1,300 ft. long are irrigated successfully. For heavy loams the lands can be considerably longer than for sandy soil, and in general the flatter the grade, the shorter should be the runs and the larger should be the head of water.

In cases where the distances between head ditches, especially cement pipe lines, prove to be too great, special methods of irrigating can be used. One method is to open an intermediate head ditch midway between the permanent ditches. The intermediate ditch can be used for the preliminary irrigation and possibly for the first irrigation after planting, after which the ground will become settled and packed and the ditch can be leveled off and planted also. In the case of furrow irrigation, double heads can be run in alternate furrows and subdivided about two-thirds of the way down the field. Later, the intervening furrows can be treated the same way, and thus the proportion of water received by the lower end is increased. Another practice is to turn a large head down each furrow at first, and when the water reaches the lower end, to reduce the head to such an amount as will continue just to reach the lower end.

Good control over the division of the stream of water into furrow streams or into separate heads for the lands is essential. Sometimes it is well to divide the stream into two, three, or more parts by means of a division box. Then each part can be more readily divided into furrow-heads. Spiles, made of laths or of narrow boards, are effective in the final distribution. The spiles are set in the ditch bank at the natural ground surface. Sometimes the water is let into forebays and then distributed through spiles. Wooden spiles are much used in the Northwest; in Arizona, however, spiles should be of some other material than wood, which cannot long withstand the alternate wetting and drying in this climate. Galvanized iron, or clay, or cement tile would be preferable. The division of water from cement pipe lines can be made with ease and accuracy, an important argument for their use.

Frequency of irrigation is a related subject. The smaller the application at each irrigation, the more often the field must be irrigated. Investigations along this line have not been conclusive except for the peculiar set of conditions under which the tests were made. Many a test has been terminated by the untimely death of the young plants when the irrigations were too frequent. Sandy soils or other soils that are shallow and underdrained by gravel need frequent applications, while a deep, rich loam, with its large capillary storage capacity, will require much fewer applications. Heavy clay soils, in some places, require frequent irrigations because it is impossible to make them take much water at an application, either because of their physical condition or because they are shallow and are underlain by hardpan that is nearly impervious.

There is much diversity in Arizona in methods of laying out fields and irrigating. Farmers in the Yuma Valley prefer to grade the lands level from end to end. Elsewhere in southern Arizona, the general custom is to run water down the slope parallel to the steeper side of the field, the lands varying from 30 to 100 ft. in width, and the lengths of runs depending on the slope, soil, crop and the available head of water. In northeastern Arizona the corrugation method is used without borders and the water is run down the steepest slopes. In Yavapai county the Colorado system of flooding from field laterals is used for alfalfa and grain.

Most Arizona soils take water readily. Uniformity of distribution is possible, but requires thought and skill on the part of the irrigator. The use of the proper unit head in each land or in each furrow will prevent waste of water in the upper or lower end of the field and will give an even appearance to the field of grain or other crop.

Wilful or Careless Waste.—This loss includes allowing excess water from the lower end of a field to run onto unused land or, as sometimes happens, into the highways. It is due sometimes to the absence of a good tail border, sometimes to gopher holes, sometimes to a sleepy or forgetful irrigator. On some irrigation projects the loss has been proved to exceed 10 per cent of the water applied. In Arizona, however, and especially in the Salt River Valley, there is a strong public sentiment against wilful or careless waste, and the total loss of this character is comparatively small. The method of measuring the water to each user and charging him for just what he uses has made the water user more diligent in distributing the water over his own fields and somewhat loath to turn it back into the system or to let it run to waste. Would that he might take an equal interest in preventing the water from escaping downward beyond his control, or upward by evaporation from a crusted soil.

In the grading of a field the lower 40 or 50 ft. should be graded level in the direction of the irrigation. The lands should terminate in one common land running at right angles across the field, or the furrows should be connected so that the furrow streams will be equalized at their lower ends. Very few irrigators are able to gauge the irrigation and shut off the water from each land at just the right time; invariably some lands receive too much and frequently the water overflows the levee at the lower end of the land. A common crosswise land prevents this loss and usually will have the heaviest alfalfa.

Water Rates and Meterage in Kansas' Cities

Ninety-three cities of Kansas out of 113 replying to a questionnaire of F. M. Veatch, acting engineer of the Kansas State Board of Health, are 50 per cent or better metered. Seventeen cities are less than 50 per cent metered and three cities sell water on a flat rate basis. Other information on meterage obtained from the questionnaire follows:

	Per cent of cities.
Meters owned by consumers	39
Meters owned by city or water company	48
Meters owned by either consumer or city	13
Meters installed by consumers	48
Meters installed by city or water company	52
Meters maintained by consumer	35
Meters maintained by city or water company	65

The following is a summary of the information obtained regarding water rates:

43.5 per cent of the 113 cities have changed rates within the last five years.

56.5 per cent have been using present rates longer than five years.

98 cities pay water bills monthly.

15 cities pay water bills quarterly.

43 cities charge hydrant rental—38 per cent of total number. Average rental, $31.40.

9 cities levy a direct tax for public water and fire protection.

For the 113 cities that replied, 102 have municipal plants; in the remainder the plants are privately owned.

Effect of Drainage Ditches on Flood Flows

One important effect of the construction of drainage ditches and levees to reclaim and protect overflow lands is to increase the flood flow under certain conditions. This is the conclusion reached for conditions in the upper Kankakee River Valley in Indiana by Mr. Samuel A. Greeley of Pearse and Greely, Hydraulic and Sanitary Engineers, Chicago, in a report made recently by him upon the adequacy and effect of some proposed drainage ditches and levees in that region.

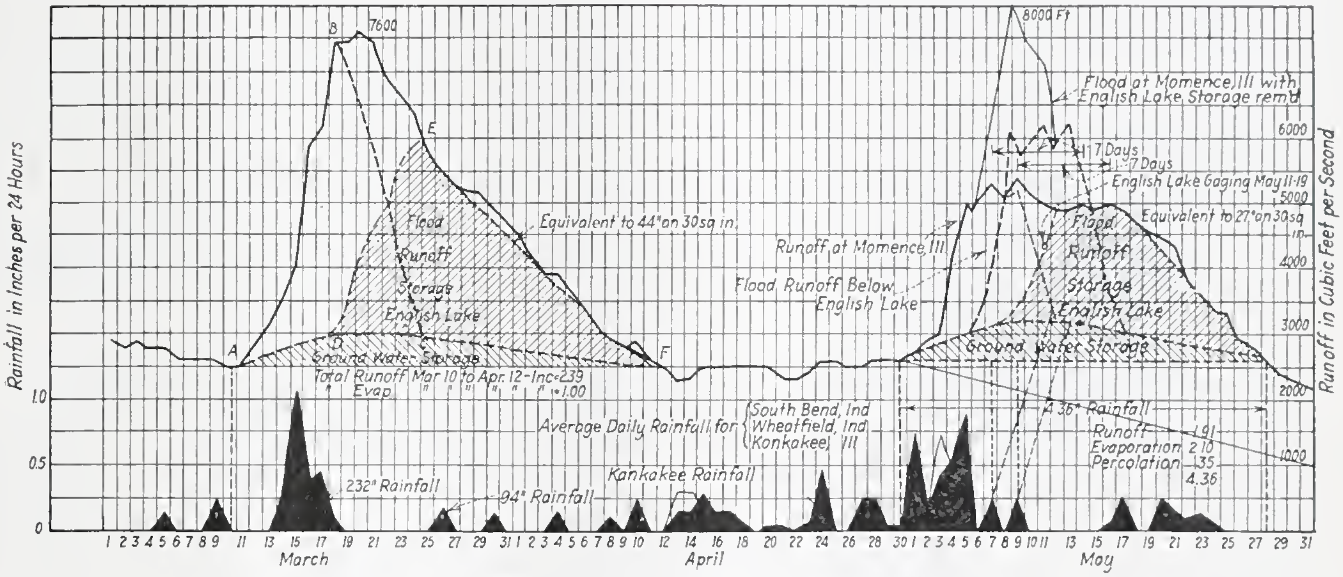
The proposed ditches comprise what is known as the Tuesberg Project and consist of a series of ditches and levees on the upper Kankakee River and the Yellow River to reclaim some 50 square miles of overflow lands for agricultural purposes. At present a portion forming a lake or swamp some 30 square miles, known as English Lake, provides considerable storage for flood flows, and with this removed under the proposed project the result would be to alter the present flood flows of the river in a very marked degree. The drainage areas under consideration are as follows:

	Sq. miles.
Kankakee River above Momence, Ill.	2,340
Kankakee River above English Lake Station	1,315
Kankakee River above Yellow River	550
Yellow River	660

A study of former flood flows and the accompanying rainfall showed that the spring rainfall, when the ground is saturated from the melting snows, is approximately equal to the run-off plus evaporation. This is illustrated by 1919 conditions when the rainfall from March 10 to April 12 was 3.26 in. The run-off was estimated from gaging to be 2.39 in. and the evaporation, according to Meyer, was 1 in., making a total of 3.39 in. The effect of the English Lake storage is shown on the accompanying diagram. The rainfall and run-off diagrams show that the peak flow at Momence occurs about 24 hours after the peak rainfall for short storms and 48 hours after the commencement of storms, continuing two or more days, and indicates a period of about two days for the run-off in the drainage area below English Lake to reach Momence. On the other hand, the peak of the flood at English Lake does not appear until about seven days after the commencement of long continued storms. There are two distinct flood waves at Momence, one from the lower and one from the upper drainage areas. Referring to the diagram the total discharge at Momence is represented by the area ABEF, the flood run-off from the area below English Lake by the area ABED, while that from the English Lake storage is represented by the area DEF. Without the flow from English Lake the run-off diagram at Momence would probably be represented by the area ABC. The total discharge from English Lake storage is equivalent to 44 in. depth on its area of 30 square miles or about what occurs during overflow.

The effect of the removal of this storage is illustrated in the second part of the diagram which shows conditions during a flood in May, 1919. It is estimated that the peak flood at Momence, Ill., would be increased from about 5,400 c.f.s. to approximately 8,000 c.f.s. The peak flood at the English lake gaging station would be increased from 3.3 c.f.s. per square mile to 14.5 c.f.s. per square mile.

The conclusions reached indicate a flood flow of 15 c.f.s. per square mile or a total of 19,700 c.f.s. to be expected once in 10 years from the area above English Lake when the storage it now provides is removed by the proposed improvements. The average annual flood is expected to increase from about 3 or 4 c.f.s. per sq. mi. to 10 c.f.s. per sq. mi.



Rainfall and Runoff for Kankakee River in April and May, 1919.

Overcoating a Steel Stack with Concrete

A 214-ft. high steel stack at the power plant of the Cleveland Electric Illuminating Co., which had begun to show the effects of age, was coated with a ring of reinforced concrete, as a measure for prolonging its usefulness. The methods employed in this work were described by Mr. C. W. Garrison in Successful Methods. The stack was 40 ft. in diameter at the base and 19 ft. at the top. The chute and tower system was employed in placing the concrete. Concrete was mixed at ground level, hoisted in small tower and carried by chutes to a receiving hopper at the foot of the high tower. There it was raised to the desired height and placed in the forms by means of an elephant trunk chute.

When ready to pour concrete the chute was swung half-way around the stack to the point farthest from the concrete tower. As the forms were filled one or two of the 3-ft. chute sections were removed so that the mixture could be placed exactly where it was wanted. After one-half of the concrete ring was poured the same operations were repeated on the other side of the stack.

This method necessitated the construction of a tower 256 ft. high—thought to be the highest wooden tower ever built The height of the top of the tower above the level of Lake Erie was 311 ft.

The total volume of concrete used was about 140 cu. yd. At the base of the stack the inside diameter of the concrete ring is 40 ft. and the concrete is 9 in. thick. At 16½ ft. from the base the concrete is 7 in. thick. The steel stack tapers to 32-ft. diameter at 34½ ft. from the base. The concrete is 5 in. thick from this point to the top of the stack. At the top the diameter of the steel stack is 19½ ft. The concrete is heavily reinforced with ⅝-in. rods and wire mesh. Wood forms were used on the first 34½ ft. and steel forms for the remainder of the height. The aggregates were heated before mixing by steam pipes extending through the material piles from the power house. The concrete was protected while setting by a heavy tarpaulin wrapped around the stack.

Work was begun late in December, 1918, and the job was completed by May 1, 1919. The rate of progress on the job depended on the speed with which the forms could be moved. The largest week's work was the pouring of six 7½-ft. sections 5 in. thick. From 9 to 12 men were employed, including hoist operators and the mixing crew. The stack was kept in continuous service during concreting.

POWER AND PUMPING SECTION

This section of the Waterworks and Hydraulic Monthly issue of Engineering and Contracting is devoted to the selection of power and pumping equipment and the economic management of its operation.

Combustion and Flue Gas Analysis

Twenty-five to fifty million tons of coal a year can be saved by the improved operation of industrial power plants without changing their present equipment, and without decreasing their manufacturing output. In order to save fuel by burning it correctly it is not enough to merely bring about the proper conditions in the furnace. These conditions, after they are once started, must be kept going, and there must be some means ot knowing positively that they are being kept up. The following extracts from a bulletin of the U. S. Food Administration describes the instruments that will furnish the means for securing this necessary information.

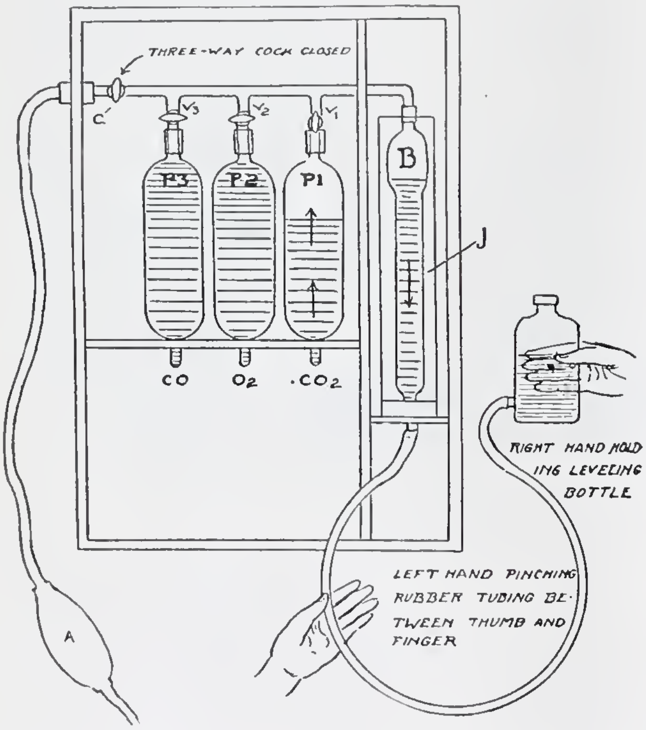

THREE-WAY COCK CLOSED
C'
V3
V2
V1
B
P3
P2
P1
J
CO
O2
.CO2
RIGHT HAND HOLDING LEVELING BOTTLE
LEFT HAND PINCHING RUBBER TUBING BETWEEN THUMB AND FINGER
A

Fig. 1—Gas Analysis Apparatus.

There is absolutely only one way to stop wasting coal burned in steam power plants. Part first of this one and only way is to insure that every particle of the carbon of the coal comes in intimate contact with enough heated air to supply 2⅔ lb. of oxygen to each pound of carbon. Part second of this one and only way to insure fuel economy is to insure that the maximum proportion of the heat developed produces steam. To do both of these things is absolutely the only way to make each pound of coal generate all of the steam it can.

To even attempt to do either without the use of the control instrument to be referred to later is simply to waste coal inevitably, invariably, and unnecessarily.

The key to the solution as regards the maximum production of heat is the control and measurement of the air supplied to the furnace; the solution of the problem as regards the maximum utilization of heat is found in the control and measurement of the temperature of the flue gases.

Now, as to the practical way of insuring the maximum production and the maximum utilization of heat; of doing what we simply must do to avoid a needless waste of coal, of money, of time; again there is one indispensable way of doing this.

1. You must determine by actual trial what conditions in your furnace, burning your fuel, produce the most steam per pound of coal.

2. Having determined these conditions, you must employ continuously methods which will maintain these conditions or which will show you promptly that you are not maintaining them. You can not wait till the end of the day to determine how much steam power each pound of coal generated—it will be too late then to recover coal needlessly lost. You must use constantly instruments which will show you that you are maintaining, hour by hour, minute by minute, conditions in your furnace and boiler which you had previously proven insured a maximum production of steam per pound of fuel and a maximum saving of heat developed.

The instruments which are absolutely indispensable to an efficient furnace control, without which fuel waste is inevitable, are flue gas analysis apparatus, pyrometers, and draft gages. The first instrument detects and determines excess air; the second measures the heat lost in excess air; and the third tends to prevent excess air.

Why the Use of a Pyrometer Saves Fuel.—In making every pound of coal develop all of its heat we take a long step toward preventing fuel waste, but if we stop here we will never insure maximum combustion efficiency.

Unless we get a maximum proportion of this heat into the boiler water, we inevitably burn more fuel than is absolutely necessary to generate a pound of steam. The larger the percentage of heat absorbed by the boilers the smaller the percentage of heat lost through the stack, and the only possible way to know what proportion of heat is going to form steam is to have a continuous record of the temperature and amount of the flue gas.

The pyrometer is the means of securing this indispensable data on temperature.

Maximum heat production in the furnace, combined with maximum heat absorption in the boiler produce maximum furnace and boiler efficiency.

General Instruction for use of Combustion Control Apparatus.—The gas-analysis apparatus most frequently used is some form of the various types of "Orsat" (see Fig. 1). The directions for its use, which may be secured from the dealer, are so explicit that skill in its use is acquired within an hour or two.

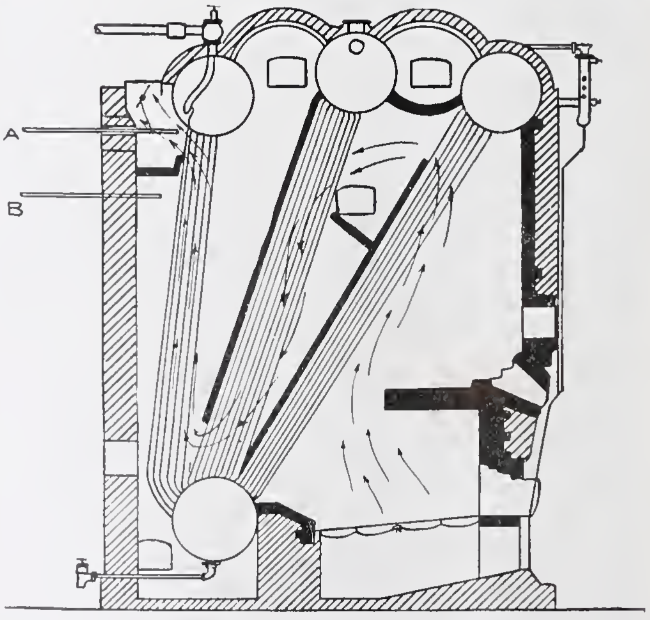


Fig. 2—Showing Correct Location of Sampling Tube.

It enables one to determine CO_2, O_2 (oxygen, a measure of the air supply), and CO in 15 to 30 minutes. No investment in power-plant equipment will pay a higher rate of interest than will a well-used gas-analysis apparatus.

Of gas analysis it may be said as of all other analyses that it is a worse than useless process unless the particular portion of material analyzed represents the average composition of the larger mass from which the sample is taken.

"A" in Fig. 2 shows the correct location of the sampling tube at the point where the gases leave the boiler, as near this as possible, and where the velocity of the gas stream is a maximum. "B" shows an uncorrect location.

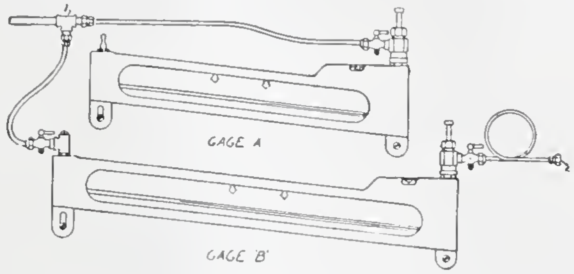


Fig. 3—Combination of Two Draft Gauges.

The sampling tube should be a ⅛ to ¼ in. iron tube inserted into the center of the gas stream. Under no circumstances should a perforated pipe, a nest of pipes, a "spider," or any similar device be used.

Pyrometers.—In order to determine the preventable heat loss from excess air it is necessary to know not only the volume but also the temperature of the excess volume.

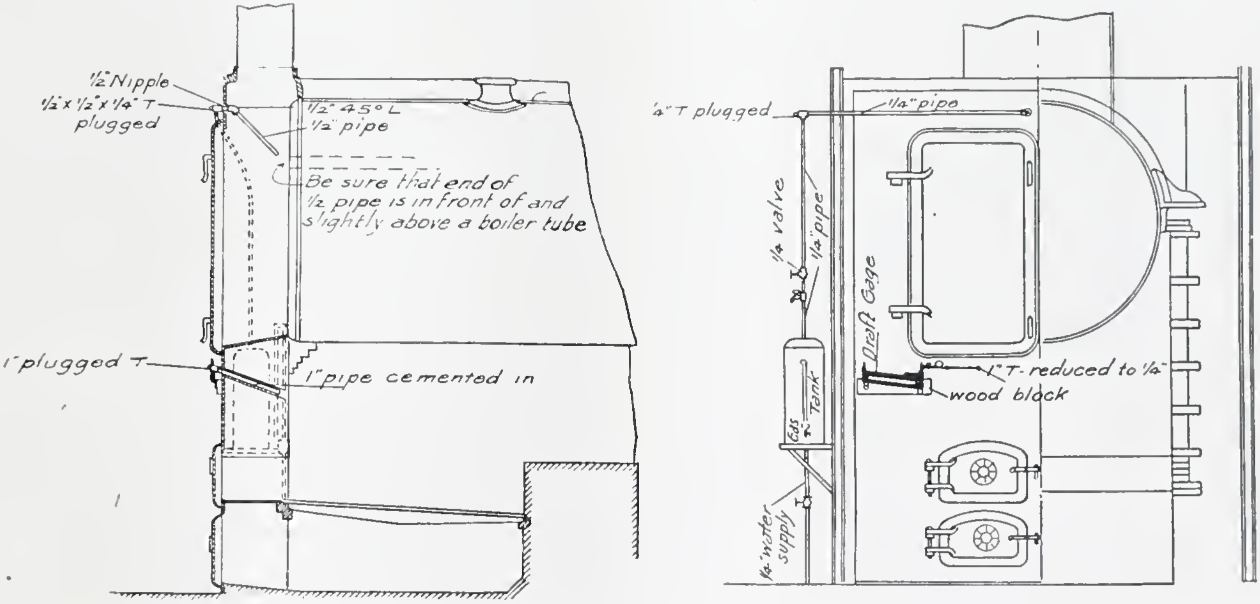


Fig. 5—Approved Method of Connecting and Mounting Draft Gauge.

The temperature should be taken at the same point as the sample of gas for analysis; that is, at the point where the gases leave the heating surfaces of the boiler, and is best determined by means of some form of pyrometer, either of the mercurial, expansion, or electric type. The latter is probably preferable because of its greater convenience.

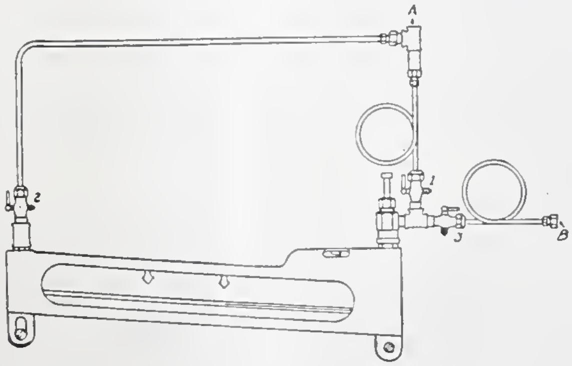


Fig. 4—Single Draft Gauge with Special Connection.

The essential parts are a "couple," which consists of two wires, usually of some special alloy, welded together, and an indicating or recording meter, connected by insulated copper wire to the couple.

To determine the temperature of the gas the couple is inserted in the gas stream where the temperature is to be taken. An electric current whose magnitude is proportional to the temperature is generated and is recorded by the meter in degrees, Fahrenheit or centigrade.

Before ordering a pyrometer decide:

1. (a) The best points in the brick setting or elsewhere to insert the couple; (b) the length of the couple to reach from that point to the center of the gas stream.
2. The place where you will locate the meter.
3. The length of the "lead" needed to connect the couple and meter.
4. The number of couples, if a switch is to be provided.

Having determined what you require, communicate with various manufacturers and state your requirements, in order to secure the equipment best adapted to your needs.

Draft Gages.—Draft regulation (see Figs. 3 and 4) is one of the most important factors in maintaining combustion efficiency.

A great deal of misunderstanding exists concerning draft gages and much misinformation regarding their application and use is current.

There is some draft that will burn a particular fuel with the best efficiency in each particular plant, but you can no more look at a furnace and tell the draft that is being applied to it than you can look at a boiler and tell the pressure within it; furthermore, drafts change with atmospheric pressure, with shifting winds, and other meteorological conditions.

As a rule the boiler nearest the stack gets more than its share of the draft, and the one farthest from the stack gets less than its share, depending on the flue connections. Many serious cases of draft troubles could be cured and fuel saved by adjusting the individual dampers to equalize the draft among the boilers. After equalizing, the drafts of all may be changed at once by using the main breechings damper.

The Best Draft to Use.—You should use the draft that will meet the load conditions and produce the best percentage of CO_2 without CO and without fusing the ash. There is practically no exception to this rule.

The maximum practical furnace temperature depends largely on the fusing temperature of the ash of the coal used; if ash slag forms under the normal of good furnace practice, the obvious remedy is to change the furnace, the fuel, or both.

The best draft over the fire for hand-fired furnaces burning bituminous coal ranges from 25 to 40 hundredths of an inch of water (the scales of most draft gages are calibrated in terms of water displacement), but it may be materially more or less, depending on the grate used, the size and ash contents of the fuel, etc. Find out the correct draft for your plant by using the gas analyzer.

It is not necessary, except for purposes of special study, to take the draft at any point except the furnace, but it is essential to have a constant indication of the draft there.

The gage should be so located that it will be before the eyes of the fireman. An experienced fireman will fire by the draft rather than the steam gage.

Figure 3 shows a combination of two draft gages; Fig. 4 a single one with special connections. Fig. 4 is probably the more practical—it will not confuse the fireman.

If desired, the draft drop through the boiler may be read at any number of points by installing the necessary pipes and cocks. A study of the diagram with attached explanation will make the manner of installing and the method of use apparent.

Point at Which to Install Draft Gage.—In installing the draft gage a point in the furnace wall, in front, should be selected as far above the grates and as near the front of the furnace as possible. Figure 5 shows an approved method of connecting, and mounting a draft gage on a horizontal return tubular boiler, also an improved method of installing a gas collector.

Draft gage "A" in the above diagram is connected to show the draft over the fire. Gage "B" is connected at the last pass of the boiler and shows the draft drop or loss between the last pass and the furnace.

The draft gage (Fig. 4) is normally used to show the draft over the fire, but it may be used to take any of the readings obtainable in the combination, Fig. 3. "A" (Fig. 4) is connected at the furnace and "B" at the last pass.

(a) To read draft over fire: Open valve 1, close valve 3, and set valve 2 to atmosphere.

(b) To read draft in last pass: Open valve 3, close valve 1, and set valve 2 to atmosphere.

(c) To read draft loss between last pass and furnace: Open valves 2 and 3 and close valve 1.

Interpretation of Draft Gage Readings.—To interpret the gage readings there are a few principles to remember. If the liquid moves toward the zero point of the scale at the often or of leaving them ajar, of leaky boiler settings, of holes are forming in them. If the liquid moves in the other direction, the fires are thick and should be burned down or perhaps raked before adding more coal.

Locate all gages where the fireman can watch them most readily and place the damper control so that he can observe the draft gage while setting the damper.

The plant owner should see that the uptake damper can be adjusted easily from the front of the boiler, otherwise the fireman can not be blamed for using the wrong method. He should be made to use the dampers instead of the ash pit doors. If he does not, the doors might be removed.

Necessity of Instructions to Firemen, Etc.—A very important measure that may be found necessary to improve the efficiency of a power plant will be instructing the fireman as to the effects of opening the furnace doors unnecessarily often or of leaving them ajar, of leaky boiler settings, of holes or cracks in the fuel bed, of too much or too little draft, etc. Encourage the firemen to ask questions and instruct them largely through your answers to these.

Explain that the gas-analysis apparatus is really an instrument for determining whether or not an excess amount of air (which means more work for him) is flowing over the boiler heating surface. Let him watch while a gas sample is being drawn and then analyzed.

Assuming that the sample shows 4 per cent of CO_2, explain that this means that the furnace is taking at the rate of 517 cu. ft. of air where it should be taking only 140; that this excess means more coal to heat up this unnecessary air and more work to handle this and the needlessly larger quantities of ashes and clinker; all leading to increased fuel and labor costs.

Let us assume that an examination of the fuel bed showed cracks, thin places, and holes, and that, after closing these by breaking up the lumps and leveling the fuel, a second sample showed 10 per cent of CO_2, indicating 107 per cent of excess air. We have by simply cutting out four-fifths of the air greatly increased the steam pressure without firing a pound of coal.

Routine Supervision.—The best results can not be secured through combustion analysis unless the work is persistently followed up and made a part of the daily routine. To bring the combustion efficiency of the plant up to a high standard is one thing To keep it so is another. The moment that the interest of the men above the firemen slackens, that moment the firemen will slacken in their attention to duty. One hundred per cent results can not be attained with anything short of a full 100 per cent equipment. Therefore, if you equip one boiler, equip all. Many make the mistake of equipping but one boiler, and the result will be that the firemen will give more attention to that boiler than to any other. They may so slight the units not equipped that the combined combustion efficiency of the plant might be less with such partial equipment than with no equipment at all.

Educating Power Plant Operators*

By W. E. EAST.

Experience leads the Toledo Railways & Light Co. to believe that the best way to educate power-plant operators is to make arrangements to let them conduct their own educational work. It is believed best to have meetings at the plant when the men are off duty and to pay the men for the time thus occupied if necessary to secure full attendance. The classes should be run on a club basis. It has been learned that if a group of men from the "front office" try to initiate a movement for the benefit of the plant men the whole plan will be viewed with suspicion. So educational work must proceed from the inside out, not from the outside in. The part of the company's officials and department heads in this work should be to make the operators feel the need of educational activities and then to let them take it up among themselves, helping them, of course, if they desire help, but never trying to force assistance upon them.

It is also believed that such abstract studies as arithmetic, physics, electricity and mechanical drawing have no place in these meetings. Men who wish to take such subjects will avail themselves of other opportunities to learn them. The real province of the power-plant club is to take up problems of ordinary operation. Questions arise daily as to the best methods of operating stokers, boilers, condensers, etc. At a weekly get-together meeting the club can handle these topics. A fireman, for example, may have ideas of his own, based on his experience, as to how to operate his stokers. The boss may have told him to run his stokers in a way that seems quite wrong, but if he is the right sort of a fireman he will be willing to learn that he is wrong through discussion in the weekly meetings.

Meetings appear to be most successful when the program includes discussion and study of only one piece of apparatus. A good plan is to have someone previously appointed to give a description of the apparatus illustrated with blueprints and catalogs. A question box should be established and used. If manufacturers' rules pertaining to operation of the apparatus are available, they should be read. Then the meeting should be thrown open for discussion by every one from the ashman to the boss. Material and literature from manufacturers should be preserved to form a reference library for the club.

Employes of the Toledo company have such a club. It is known as the Water Street Boiler-Room Club, becuase its membership consists of practically every boiler-room operator at the Water street generating station. A boiler-room fireman was instrumental in organizing it, and the men have supported it enthusiastically, electing him president. All suggestions are acted on by the club before the reports of those suggestions which seem worth while are submitted by the club president to the superintendent of production. The club, in general, works along the lines discussed above, although it also engages in some social activities. While the club is still young, successful results thus far indicate that it will serve to promote general welfare of the men and the company.

Personal training is also being given to the firemen in connection with combustion tests which are run by the results department. These tests are made for the double purpose of checking up the accuracy of the boiler-flow meters, draft-gage settings, etc., and also to enable the firemen to become familiar with the use of these instruments. The man who is running the tests and the fireman get together, and the tester tells the fireman that he wants to get the fire as hot as possible. He then shows the fireman what his boilers are doing, provided the boilers are equipped with meters, and they set out to improve conditions, if possible. Readings are taken of draft, boiler output, air flow, analysis of flue gases, stack temperature, etc., and the fireman is informed of all these readings as they are taken. Then as conditions are improved the results are pointed out to the fireman and he is shown how his boiler meter will guide him in his everyday operation of the fires and enable him to obtain the best results at all times. As an incentive to the fireman to make good records, methods calculated to inspire rivalry are pursued.

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*From a paper presented before the Station Operating Committee of the Ohio Electric Light Association.

At the Water street station the company also has a fireman's instructor, whose duties are to break in all new firemen and to teach them to make full use of all the boiler instruments. This man also supervises all the fires on all special tests and in that way keeps in touch with all the testing work which is carried on in the boiler room.

In conclusion, the company believes that much good can be done in an educational way along three lines: General work, which takes up the fundamental subjects; the special classes, which include the operators' clubs, and the personal work, which is intended to give individual instruction. However, it is believed that the most successful endeavor and the one most profitable to the company is the operators' club. From experience that appears to be the best place to start. After this club is in full operation the demand for more academic classes will become greater and the personal work will become easier and will accomplish more.

Fallacy of Haphazard Boiler Room Records

While there is no doubt that the records of the operation of central station equipment can play a large part in increasing the efficiency of the plant, it is also true that records that are not accurately kept are not only useless, but may be the cause of much wasted time and effort, states Mr. C. C. Raitt in Power. There is no meter that will run on indefinitely and give accurate results without periodic checking, and this is especially true of the flow meters available at the present time. Flow meters have not yet reached a stage where they can be considered sturdy.

The conditions under which they are expected to operate are anything but desirable for a delicate mechanism. There is invariably a quantity of fine coal dust in the air around a boiler room, and there is sure to be considerable vibration in the building. Therefore, if there is to be an accurate record of steam flow, someone must make frequent inspection of the meters and keep them clean and carefully adjusted.

In many cases where flow meters have been installed and readings used for various calculations month after month, it has been found later that the meter had gotten out of adjustment and the readings were all wrong. No doubt there are instances where it is impossible to get a check on the flow meters and know whether they are working properly. When this is true, it is doubtful if the meters are a wise investment. However, in most cases, the capacity of the turbines or the boilers metered, together with the readings of other meters working in conjunction, should give a sufficient check on the readings of a meter.

At this point it would be well to explain just what is meant by checking a meter by the capacity of the equipment metered. It certainly does not mean that an estimate of steam flow, based on the capacity of the equipment metered, is to be given precedence over the readings of the meter and used whenever meter readings do not look satisfactory. But it does mean that whenever the meter readings do not agree with the estimate, it is time to hunt the trouble.

It should be hunted first in the meter, and if the meter is proved to be correct the reading should hold and the trouble should be hunted in the metered equipment. There is always a tendency to assume that the operation is normal and the meter wrong because it is so easy to estimate what the reading should have been and let it go at that. But whenever this is done, the purpose for which the meters were installed is defeated. A meter reading should be considered right until it is proved wrong.

In determining the pounds of coal burned in the plant a number of difficulties arise. Where the coal burned is not of uniform size, it is difficult to obtain the weight by measuring volume. Even though it may be bought in uniform size or crushed in the station yard, there is still the danger of ice causing lumps to form which interfere with the measurements. It is best to weigh all the coal burned if possible.

Here again, there is an opportunity for errors unless the weights are automatically recorded. It is only human to make mistakes and to be negligent where there is no check on a man's work. Therefore, to trust an employe to put down the weights without any way of knowing whether he is doing it properly or not is to invite trouble.

If it is true that the automatic mechanisms we use need care and attention, it is even more true that the human element in our records must be watched. And so it is not enough to provide means for weighing all coal burned, but some method—automatic if possible—should be used to make sure that all coal is accurately weighed.

Examples of Economies Effected by Softening Water

There is a very direct relation between softening water for use in boilers and saving fuel. The following examples of such economies are abstracted from an engineering bulletin of the U. S. Fuel Administration:

A marble company reports a saving of 21 per cent of fuel by softening its boiler water.

A crucible steel company, by substituting soft for hard water, effected a saving of 3,600 tons of coal per annum, which based on current prices would be valued at about $22,000.

The Chicago & Northwestern Ry., comparing its operating expenses in 1902-3 before and after softening its water supply reported a saving of $75,000 per annum. This saving was effected at a period when coal cost probably less than one-half the prices charged in 1918.

In addition to these, other cases have been reported in which the profits resulting directly from the substitution of soft for hard water have been reported as varying from 32 per cent on an investment of $7,200 to 71 per cent on an investment of $7,000. These profits resulted largely from the elimination or reduction of operating costs, such as cleaning heaters, piping, and economizers, cost of cleaning instruments, interest, and depreciation on spare or idle boiler, etc.

Furthermore, it has been estimated that the use of hard water in a great number of the locomotive boilers of the country involves the consumption of 15,000,000 tons of coal more than would be needed were soft water only used.

A steel company, whose annual output is 50,000 tons, reports a saving of 200 lb. of coal per ton of steel resulting from the softening of its boiler water.

10 Hints for Storage of Bituminous Coal

Tests conducted by the Bureau of Mines lead to the following conclusions regarding the storage of any bituminous coal.

(1) Piles not to be over 12 ft. deep, and no part of the interior to be over 10 ft. from the surface.

(2) Store only screened lump coal—if possible.

(3) Keep out dust as much as possible, and to do this avoid handling.

(4) Have lump and fine evenly distributed. Do not let lumps roll to the bottom and form air passages.

(5) Rehandle the screenings after 2 months, if possible.

(6) Store away from any sources of even moderate heat, and well away from the main buildings of the plant; never against a frame building.

(7) Allow 6 weeks seasoning after mining before putting into storage piles.

(8) Avoid alternate wetting and drying.

(9) Avoid admission of air to the interior of the pile through interstices around timbers, irregular brick work or a porous bottom such as coarse cinders.

(10) If wet coal is received, dump in small piles around the edges, where air can get to it freely to carry away moisture, and where other coal will not be packed on top of it.

Bonus Plan Increased Boiler Plant Efficiency 35 Per Cent.—In a discussion at the 1918 annual meeting of the American Society of Mechanical Engineers, Mr. Edward N. Trump stated that his company had raised the efficiency in boiler plants from 50 per cent average to 85 per cent, largely by giving a bonus to the firemen so that it was to their interest to save coal. He said that at least 10 per cent saving could be made in almost any plant by using such a plan. The values measured were carbonic acid in the flue gases, water fed to boilers and carbon in the ashes. From these the efficiency can be determined and a suitable reward offered for improvement and maintaining the improved efficiency.

MANAGEMENT AND OFFICE SYSTEM

This section is published twice a month: (1) In the Waterworks and Hydraulic Monthly issue, and (2) in the Railway and Excavation Monthly issue. It covers what may be broadly termed "management engineering" as applied in the civil engineering and construction fields.

The Army Method of Testing Men's Abilities

On February 24 of this year Lt.-Col. John J. Swan, U. S. A., delivered an address before the New York Section of the American Society of Mechanical Engineers in which he outlined the methods used in testing the abilities of applicants for skilled positions in the army. This address is abstracted in the May issue of the journal of the society, "Mechanical Engineering," under the title, "The Right Man in the Right Place in the Army"; and as some of the methods outlined are of a character which should prove useful to many civilian employers, the descriptions are given below. The men's own accounts of their abilities afforded a painfully inaccurate statement of the facts, for—of 425,000 men received in the draft up to Dec. 15, 1917, reduced to the basis of 10,000 white and averaged over the entire country, it was found that there were only 50 bakers, 90 blacksmiths, 8 bridge carpenters, 90 butchers, 190 cooks, 150 electricians, 8 farriers and a small representation of the other trades essential to the operation of the Army. These figures are based on the statements of the men themselves as interviewed by the Personnel Officers, but when the men claiming these trade abilities were examined or tested by the system employed by the Personnel Department it was found that only 6 per cent were experts, while 24 per cent were journeymen, 40 per cent apprentices, and 30 per cent without any experience whatsoever.

System for Rating Officers.—With 195,000 officers in the service at the end of the war, it is evident that very special means must have been used to secure a proper personnel. Briefly, the system is based on giving to each officer a rating which is made by his immediate superior and which rating is determined quarterly so that the improvement or change in the officer's work or ability can be credited at frequent intervals.

The system consists of each rating officer preparing for himself a scale of measurement in accordance with a simple yet effective method which can be understood by all and is universally applicable. This scale considers separately the essential qualities of the officer, such as physical qualities, intelligence, leadership, personal qualities and a general value to the service, and the rating officer considers such officer whom he has to rate in the light of these qualifications one by one as contrasted with the officer on his scale.

In preparing his scale for rating any group of officers under his command, he thinks of the purely physical qualities of all officers of his own rank with whom he is acquainted and visualizes the physique, bearing, neatness, voice, and endurance of each, irrespective of any other qualities. Among all those he has in mind, some one will stand out pre-eminently and he writes down the name of this particular officer as highest. Another one will rank slightly lower, still another about average, another low, and finally one will be visualized as being lowest in the quality named.

In a like manner he then selects five officers on the basis of their intelligence, another five for their leadership, others for their personal qualitles, and finally those whom he believes to be of value to the service.

The rating officer then has a scale under five general headings with five names under each heading ranged from highest to the lowest with purely arbitrary factors of value opposite each name. It should be noticed that in the preparation of this scale it makes no difference whether a general or first lieutenant has worked it out, for in the preparation of the scale any conscientious officer can do this who has considered essential qualities and has made up his scale ranging from highest to lowest of men of his own rank with whom he is personally familiar.

Referring to a chart not reproduced herewith, the article says: "This chart indicates in a general way that, barring a few exceptions in a neutral zone, it would have been possible in the first instance to select candidates by some form of intelligence test, and thereby practically double the capacity of the training camps. The diagram in the lower half of the chart indicates in like manner the result obtained with the 1,458 non-commissioned officers, and in this the same argument holds."

No Trade Tests.—Owing to the diversity and number of trades encountered, a very thorough study was required in determining whether tests could be applied and if so what character of tests was necessary. As a result three forms of Trade Tests were developed, sometimes applied singly and again two or all three used. The first of these is the "oral trade test," in which the candidate or recruit is asked a series of standardized questions which have been prepared with the greatest care to eliminate ambiguity and localisms or catch features. A trained interviewer or tester asks the questions exactly as printed and in accordance with simple but very definite rules, and the recruit answers to the best of his ability. For the benefit of the tester, the correct answer, or several answers if more than one is possible, are given under the questions. If the recruit answers correctly he is given a maximum score. If his answer is partially correct in accordance with a definite schedule, he is given a partial score. After all of the questions have been answered and scored by the tester, the total is taken and compared with the rating scale, which scale gives the terms Novice, Apprentice, Journeyman, and Expert within certain numerical limits. In other words, in the case of the tailor's test, a score of from 18 to 37, inclusive, would give the recruit a rating of Apprentice; 42 to 56, inclusive, Journeyman; and 59 and above, Expert.

The second form of the test is known as the "picture test," and employs pictures of certain essential tools or devices of the trade with which a man who has or can perform in the trade must be familiar. In this test a sheet of numbered pictures is given to the recruit and the tester holds a corresponding question sheet with questions and answers corresponding to the numbered pictures. The recruit must name the various tools or appliances and the tester scores up and gives a rating as in the former case.

Test to Determine Candidate's Abilities as Motor Truck Operator.—The third and last test consisted of an actual demonstration of the recruit's abilities. In the case of truck or auto drivers a course was laid out and each candidate was required to perform certain definite operations in a definite sequence and under identical conditions. If in doing this work he fails to perform all of the operations or does certain other things against which he is warned, he receives less than a perfect score. As in the former cases, totaling the scores gives a figure which enables the man to be rated as a Novice, Apprentice, Journeyman, or Expert.

In operation, the system is as follows: A recruit having claimed more or less ability as a truck driver when being interviewed in the first instance, is given an oral Trade Test, and provided he is classed by the interviewer as an apprentice, journeyman or expert in this, he is ordered to present himself at the performance-testing station at a definite time. On arrival at the testing station or truck course he takes command of a standard truck with a tester or scorer on the driver's seat with him to give instructions and score him for results.

The scorer instructs him to drive up to Post 1, which is the start of the test. He is then told to drive to Post 2 and on to Post 3 round a curve. The scorer then tells him to back up to Post 2. This little preliminary run indicates whether the recruit can drive a car at all, and gives evidence of sufficient ability to proceed with the remainder of the test. It also gives the man a familiarity with the throttle and gearing and "feel" of the particular machine to be tested. The scorer then instructs him to drive on to Post 4 and turn to the left and enter the S or reverse-curve section outlined by vertical posts or stakes. He is instructed to drive through this S at whatever speed he regards as best and must not stop nor drive in a jerky, irregular manner, and he must not knock down any stakes. In emerging from the reverse curve to the large square he is required to drive close up and with his hood at the center of the board at station 5. The scorer then instructs him to back away and around the semi-circle section to the second square and continue backing until the tailboard is close up to and in the center of the board 6, which is supposed to represent a loading platform. He is then told to run forward close to Post 7, where he stops on the grade, and then start and run up to the top of the grade, turning around with no more than one backing and without stalling engine or grinding gears, and then to run down tbe incline to the starting point. Careful instructions are given and all candidates are treated alike. It will be seen that the conditions of this test are very exacting, and it has been found that any man who gets a score of Journeyman or Expert in the test can subsequently make good under any conditions of service

In accordance with the plans 92,550 truck drivers, 36,000 motorcycle drivers and 30,000 automobile drivers were needed overseas. These tests effected an enormous saving in maintenance and repairs because valuable transportation equipment was not turned over to inexperienced or incompetent men to be wrecked in a few hours, but was put in the hands of men proved to be skillful both in operation and care of their equipment.

The motorcyclist's test and the auto driver's test are in principle the same with varying details, inasmuch as conditions of practical operation vary somewhat from the truck driver's. It is interesting to note that these tests are at least in principle the rebirth of a system employed by the French in the very early days when automobiles were just beginning to appear in France, which was really the pioneer in automobile use. The municipal authorities in Paris, and later in other continental cities, and still later in a few instances in the United States, employ practical tests of this sort before issuing licenses to drivers.

Test for Carpenters.—Carpenters were in great demand and to obtain these men the following test was employed: The recruit receives a blueprint or working drawing with dimensions and full instructions as to what is required in the finished piece. The material and tools are standard throughout and wherever the tests are conducted. The work to be performed consists in ripsawing a slab from one side of a 2-ft. piece of 2x4 rough scantling, in chopping with a carpenter's hatchet on one edge, planing of one face and edge and chiseling a smooth dovetail mortise at one end of the piece, all in accordance with the dimensions in the instruction print. The particular job has been prepared after extensive study with an idea of requiring a minimum amount of material and reasonable time, and yet to permit the fundamental operations required of a general carpenter, such as ripsawing, chopping, planing, chiseling, squaring, working to dimensions from a drawing or blue print, etc.

Tests were also devised for linemen, patternmakers, inside house wiremen and blacksmiths, and since these trade tests were instituted about 250,000 soldiers have been tested.

Conclusions.—These tests also emphasize the fact that it is not possible to accept a man's statement of his trade ability, for while the majority of men endeavor to tell the truth, each man's judgment of his own ability is nevertheless not comparable with any definite standard.

Briefly, the steps necessary in giving trade tests are:

1. The procurement of the necessary information.
2. The preparation of questions on the basis of this information.
3. The test of data and the revision of such questions or tasks.
4. The second revision.
5. The practical tryout to insure the value of the various questions for checking trade ability.
6. A further analysis and check.
7. The preparation of the tests in final form for practical use.
8. The accumulation of further information bearing on results of the tests with the idea of improving them if it is thought necessary.

An Unusual Collection System Co-ordinated with Selling Operations

Under the title, "We Don't Standardize—and It Pays Us,' Mr. H. Uehlinger, assistant treasurer, Hilo Varnish Corporation, writes in "System" for September of how his company is using as careful psychological methods in making its collections as it uses in making its sales. The customer's preferences as to time and manner of payment are sought, and if within reason, are met. Information on this point, as well as on the customer's personality otherwise, is obtained largely from the salesmen; and collection methods are determined accordingly, with due regard, of course, to the customer's rating and previous record. Monthly statements are not sent except on special request of the customer.

We quote from Mr. Uehlinger's article as follows:

I believe that all but comparatively few judgments can be made properly from the ledger sheet. All that the credit man need have in mind is: deliveries not posted; checks not credited, and orders in process that have not been billed. With the ledger before him, the writer of the collection letter knows pretty surely the proper point of contact.

To make sure that the least possible time will elapse between the transaction and its posting to the ledger, we have worked out a very satisfactory method.

We have divided the country into districts; each district is controlled by a sales ledger. Every morning all the entries, debit and credit, applying to district No. 1 are posted and passed to the collection office, where they receive immediate attention with reference to collections. When district No. 2 is posted by the accounting department, it is likewise passed over. In the meantime the collection department has finished with the ledger of district No. 1 and returns it to the accounting department. When an accountant is posting an overdue account, he writes the details of the payment on the last sheet in the overdue folder which is filed with the ledger account, and he also removes the folder from the ledger and passes it to the collection office.

Incidentally, you will notice, this method does away with the necessity for keeping an expensive set of duplicate records on our customers.

But when the ledger sheet does not give all the necessary information, we must refer to the letter files. By our plan, the letter files are in the ledger.

Our folders are the same size as the ledger sheet, and therefore fit in the binder. Thus the collection manager has instant access to every bit of information on every account. From the information that the folder gives him, he is able to visualize the debtor. The window in the folder saves writing on it. We therefore use each folder over and over again.

Records of all telephone calls and verbal credit agreements as well as copies of letters, go into this folder; thus it gives a complete history of the account from maturity to collection. Different colored folders designate various territories and ledgers for ease in filing.

To show that accounts are overdue, we use tab signals along the top of the ledger sheet, which is numbered from 1 to 31. The first tab is red, the second white and the third blue. Red indicates August; white, September; blue, October. And on September 1, red begins to mean November. In this way we have a range of three months.

It is then not difficult for the dictator to get a letter through quickly, especially since in our office we use personal form letters in our work. Although we call them form letters, these letters differ considerably from the usual form letter. They have been produced from 700 tested letters which we sent out from time to time. They are grouped in book form so that any one of them can be referred to instantly. Each stenographer has a copy of this book.

Now, when the time has come to send out a letter, the collection manager picks the letter which fits exactly and inscribes its number on the statement of the account to be collected.

The typist then writes the letter, filling in any blanks with facts revealed by the statement. Needless to say, this demands that the typist bring to her work more than a mechanical ability—and spirit. The original of the letter goes to the customer, the first copy to the salesman who covers that district, and the second copy to the file in the ledger binder.

If there is no response to a statement or a letter, the account automatically comes up for action again because of the marginal tabs.

Sectional Maps Filed Compactly and Displayed Conveniently

The following is abstracted from an article by E. J. Buchaca in "System." The maps in the instance described were used for exhibiting information as to salesmen's routes, the location of each salesman, railroad rights of way, telegraph and telephone lines, shipping route, and so on.

"In a constantly developing territory, the maintenance of the maps that may be necessary is often an item of considerable expense. In preparing our maps, therefore, we were confronted with the problem of making them show as much information as possible, keeping them posted to indicate the latest conditions and doing this at a minimum cost."

After reciting some of the difficulties experienced with files of the window shade roller type, and objections to swing-racks such as are used for the display of picture post cards, the author continues:

When we got down to the details we found that only a comparatively small part of any territory could be seen at one glance, unless the leaves were very large. We then conceived the idea of having the maps mounted on fibre wall board of a convenient size and arranged to slide in grooves or tracks along the wall. In order that any one of the mounted maps might be placed end to end with any other, we needed a track for each map. As there were to be 20 maps, each measuring 36 by 47 ins., we feared that the tracks would extend too far from the wall. But we had them made of metal, and required only 13 ins.

At the end of the track we built a housing for the maps. This was constructed of sheet metal, with a door at the far end so the maps could be slid out for changes. The maps were mounted on the board and coated first with shellac and then with a good quality of varnish.

To prevent warping, we had a sheet of paper pasted on the back of each mount, and this too was covered with shellac and varnish. The edges were bound with nickel-plated steel. The vertical edge which was at the open end of the housing when the map was under cover, was made wider than the others, so that it would almost touch the edges of the neighboring maps when in the case and tend to make the housing dustproof. On this edge we had a handle placed for each map.

In order to be able to use ink on the varnished surface, we found it necessary to rub the surface down a bit with "rotten stone," and in the case of the black ink, we used to add just a little glycerine to avoid flaking.

One great advantage of these maps, we have found, is that erasures can be made readily, by means of a damp cloth, without injuring the surface. They may be cleaned with gasoline without disturbing the inks, whereas with the maps we formerly used the ink would get under the surface because of the cracks, and it was necessary to cut into the map to make erasures. Further, we had no way of cleaning them.

Another advantage lies in the fact that the maps can be taken out one at a time and corrected while other people are using the rest of them. We have also found that much neater drafting work can be done on these maps. As a result, a greater amount of information can be placed on them, making a more satisfactory record in every way. It is of interest to note that the whole outfit—housing, tracks, maps, mounting and edges—costs only about $200, or $10 per map.

Referring to a set of charts which was subject to frequent change and rather hard usage; and to the trouble, expense and danger of error involved in keeping both a working print and the tracing up to date, the following is offered:

Using the tracings themselves as the records has proved very satisfactory. This was quite a departure from our former methods and the natural objection came up that the tracings would not stand wear and tear. To avoid this difficulty, we had some heavy paper, with the edges turned over, fastened to the stick, and then the tracings were placed in the frame formed in this way. The tracings were held to the paper with fasteners, and to the stick with small screws and washers.

More than a year's use has proved the value of this method. The chart tables have been eliminated along with the charts. The tracings are now always up to date and prints can be obtained from them at a moment's notice. The expense of making up new prints and mounting them periodically has also been entirely eliminated.

The Economic Administration of a Supply Department

That tremendous wastes may be insidiously concealed in the purchase, storage and distribution of supplies, is forcibly pointed out by Henry B. Spencer, Director, Division of Purchases, U. S. Railway Administration, in an address presented at the September meeting of the New York Railway Club. Mr. Spencer's observation is that the purchasing and the handling of supplies are so intimately related that all matters pertaining thereto should be concentrated in a single department under the direction of an executive officer. On the other hand, he finds that finance and purchase, which at times have been combined, are not so intimately related as might be supposed and should be separately administered.

Study of the affairs of undertakings very much smaller than our great railroads would doubtless reveal many cases of similar losses, and the possibility of their correction by similar means. The magnitude of the sums involved in the case of the railroads commands attention.

The railroads under Federal control annually purchase material and supplies of all kinds to the value of approximately $1,700,000,000. Since the organization of the Division of Purchases, it has expended directly $400,000,000 for rolling stock and $9,000,000 for rails, and has quite directly supervised the production and distribution of 120,000,000 cross ties which have cost $90,000,000.

The Railroad Administration is not often thought of by the public as an economizer, but from Mr. Spencer's account, it appears to be saving at least on its stores. He says:

At the beginning of Federal control the railroads had reserve stocks of material in their possession aggregating in value $495,680,000. The difficulty of obtaining deliveries of material within any reasonable time and the higher prices paid for such as was obtainable, resulted in greatly increasing the value of these stocks, which on July 1 of this year had reached the enormous total of $642,192,000, an amount, by the way, which is much larger than necessary. It is gratifying to be able to report that through the co-operative effort of the Federal managers and their respective organizations these large balances are being reduced. (Since January 1, $14,000,000 worth has been transferred.)

"It became apparent that the best results were being obtained by those railroads which had entrusted this work to a department created exclusively for that purpose, and to which was given the sole responsibility for the proper care and distribution of the material and the accounting for its receipt and disbursement."

The amount of material in stock on July 1, 1919, represented an average supply sufficient for six months' operations, based on the average monthly consumption during the first six months of the year. Those railroads which have maintained for some years well organized and effective stores departments have been able to so control their investment in material that it did not exceed an average of four months' supply. If all of the railroads had been equally well manageed in this respect they would have expended approximately $215,000,000 less for their material than they actually did expend in the last 18 months.

Relation Between Purchasing and Stores Departments.—It further became apparent that the relation which existed between the work of the purchasing department and the stores department was so intimate and their activities so vitally interwoven, and that the results which were being obtained on railroads which had recognized the affinity of these departments in their form of organization, were so much better as a rule than those obtained on roads where this relationship was not recognized, that it was determined to combine the operations of the stores department with those of the purchasing department, under the jurisdiction of the Division of Purchases, and joint instructions to that effect were issued by the directors of the Division of Operations and the Division of Finance and Purchases in October, 1918, the general tenor of which was that an independent stores department reporting to the purchasing agent should be organized on each railroad under federal control.

The necessity for a strong organization working along well systematized and effective lines to properly care for the vast amount of materials in which the railroads have so large an investment, may be illustrated by the following approximate figures, comparing the amount of money spent for material by the railroads under federal control with their operating revenues and expenses:

Approximate average daily operating revenues	$12,600,000
Approximate average daily operating expenses	11,300,000
Approximate average daily purchases	4,600,000

(These purchases do not include any rolling stock.)

It will be seen that out of every dollar earned 36½ ct. is expended for material.

A Common Economic Fallacy.—One of the fallacies indulged in by the average railroad operating officer seems to be that he does not regard money expended for material as being money spent until it appears in and affects his operating expenses. To this fallacy I attribute much of the apparent lack of interest on the part of railroad executives to bestow the same careful attention on the stocks of material which are accumulated by their subordinates that they give to the other details of their business. As soon as money has been transformed into material, it has apparently lost all value until it reappears in the shape of an operating expense, and some of us have not yet learned that it requires even more diligent attention to prevent serious losses through improper care in the purchase, distribution and accounting for material than for the money itself which it represents.

For a great many years it was one of the accepted theories that the users of material were the men best qualified to determine the amount which it was desirable to provide for future use, to care for the material which had been provided, and to account for its ultimate disposition.

To this theory is due the unnecessarily large accumulation of material found on many railroads. It is still being acted upon in some cases, although its validity has been disproved by the advance which has been made during the past 15 or 20 years in the methods of handling this important branch of railroad operation.

It has been effectively demonstrated that this work can be more economically and efficiently performed by an organization devoting its entire attention exclusively to that feature of the business and working independently, but in co-ordination with those departments whose functions include the using of the material. The sole function of the stores department is to provide materials and supplies suitable for the service for which they are required, when and where they are needed and at the lowest net cost, which involves the work of properly storing and protecting the property until it is used and accounting for it accurately.

Ideal Form for Service of Supply.—The receipt and distribution of material is so intimately involved with its procurement that they cannot be successfully disassociated, and experience points directly to a combination of the purchasing and stores department under a single authority as the ideal form of organization foor the service of supply.

It should be immediately apparent that the officers who are entrusted with the investment of 35 per cent of the gross earnings of a railroad should be men of character, ability and experience. Responsibility of this magnitude cannot be successfully placed upon shoulders of incompetent or inexperienced men without resulting disastrously, but with the proper personnel results can be and are being procured which seem almost incredible to those who still adhere to the theories and practices of the past.

Illustrating the possibilities of the case, I quote from the performance records of two typical railroads, one above the average with an efficient organization such as I have attempted to describe and one below the average which has not as yet fully developed its stores department along the lines indicated.

Road A at the beginning of federal control had $11,840,000 invested in the ordinary run of material, exclusive of rail, ties and fuel. This represented 5.6 months' supply, based on the average monthly consumption for the first six months of this year, and was abnormally high due to large purchases made at the low prices prevailing prior to the entry of this country into the war.

During the 18 months ending June 30, last, this railroad has reduced this investment 17.5 per cent, or $2,079,000, and is currently using 21.5 per cent of its stock every month, or turning it over more than two and one-half times per year.

Road B, a smaller road, which should therefore be more easily controlled in such matters, had an investment in similar material of $6,955,999 at the beginning of federal control, which represented 5.1 months' supply on the same basis. During the same 18 months' period this railroad increased its stock $4,731,000, or 68 per cent, and on June 30, 1919, had an investment of $11,686,000, of which it is currently using only 11.5 per cent monthly and has enough money tied up in material to last it for approximately nine months.

If the supply department of the latter railroad had been as effectively organized and managed as the former, it would have expended $5,951,000 less for material than it actually spent during the last 18 months, or $330,000 per month. It would have had that amount free for other uses and would also have avoided the expense of handling and caring for this large amount of stock as well as the inevitable losses incident to depreciation and obsolescence which accompany such unnecessarily large accumulations of material.

After carefully studying the practical results which have been obtained by the various railroads under federal control, it is my conclusion that the best means of enabling executive officers to obtain effective supervision and control of these large expenditures is to concentrate the exclusive management of the service of supply in the hands of a single organization created for that particular purpose and to which should be entrusted every detail of the work of procuring, storing, distributing and accounting for all supplies of every description that are required for the maintenance and operation of the property. Under such a system there is no division of authority, and there can be no shirking of responsibility. The records of performance present a complete and comprehensive view of the entire situation with respect to the total investment of the railroad in materials, and render that investment more responsive to the current needs of operation and easier of effective control.

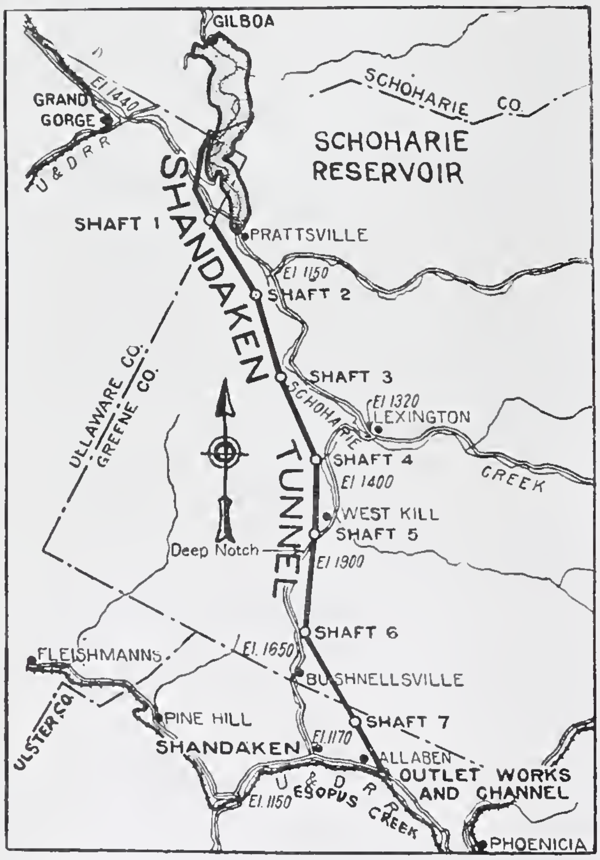
It is not possible to accomplish this where the authority and responsibility for the amount of the expenditure and the custody of the material is divided among several different departments and where the accounts are distributed among numerous independent units, which renders the work so intricate that the combined results cannot be presented in a manner that permits the details to be clearly grasped without laborious research.

There is a natural tendency to shun the expense involved in any work which does not of itself produce a direct and tangible income, but from the figures I have quoted no one can doubt that Road B would have been fully justified in adding $100,000 or even $500,000 a year to the payroll of its supply department if by so doing they would have created an organization which would have functioned as effectively as the one which Road A has built up.

Wooden Water Mains at Boston.—In putting in high pressure water mains recently at Boston, Mass., workmen dug up about 50 ft. of wooden water mains installed in 1789 and used continuously until 1840 for bringing water from Jamaica Pond in Roxbury to this city. The pipes were installed by a corporation formed at the instigation of Gov. Samuel Adams, with authority to hold $33,000 worth of real estate and to issue 100 shares of stock. In all, 15 miles of these water mains were laid, serving a fairly large section of what is now down-town Boston and was then the whole town. At the height of prosperity the service supplied 1,500 houses with water. They were replaced in 1840 with 10-in. iron pipes. The wooden mains are approximately 16 in. in outside diameter, left in their natural condition on the outside, except for removal of the bark, with 4-in. and 2-in. bores through them. Transversely there are ⅜-in. and ½-in openings in which were inserted lead pipe used in conducting the water to the houses. The sections of pipe were cut off at right angles and lead couplings used to connect them. The wood is said to be pitch pine. The outside surface is rotted, but the inner wood is stated to be still hard and apparently as good as ever.

Shandaken Water Supply Tunnel Job Will Require 2,000 Men for 5 Years

The lessons learned from the army cantonment experiences in housing and feeding men have been applied to the construction camps installed by the Degnon Contracting Co., New York City, for its Shandaken Tunnel contract. This tunnel is a part of the Schoharie development of the Catskill water supply of New York City, and probably is the largest job of its kind now under construction in this country. The tunnel will be 18 miles in length, and with the exception of about 600 ft. at the portal, will be through bluestone formation, laying in horizontal strata and carrying very little water. The tunnel has eight shafts, and one portal, located as shown in the accompanying map. The shafts vary in depth from 255 ft. to 640 ft. All the shafts except the intake one are finished, and work on the latter and the portal cut is now in progress.



Map Showing Location of Shandaken Tunnel.

Electric power for the work is obtained from the Central Hudson Gas & Electric Co. over a transmission line about 48 miles long. The power is furnished, at the shafts, at 33,000 volts—3-phase, 60 cycles—and stepped down, at shaft 7, for use on the compressors and hoists, to 2,200 volts. At the other shafts the voltage is stepped down to 440 volts. For use on the pumps and smaller motors, the current is again transformed down to 220 volts. Transportation in the tunnel will be by means of electric motors, using storage batteries on short hauls and trolleys on long hauls.

A very efficient ventilating system is being installed. Connersville blowers, with a capacity of 750 ft. per minute at 10 lb. pressure, being provided for each heading. It is intended solely to use the blowers for getting air into the tunnel, and not to rely at all on suction. Standard weight 6-in. steel pipe is being installed to conduct the air to the heading.

Leyner drills are used on all the rock work.

Each shaft is provided with two cages, operated by electric hoist, for the hoisting of men and material. These cages are provided with all the necessary safety appliances.

The living accommodations for the men were built by the contractors and are very complete. They include separate barrack houses for each 28 men, with an air allowance of 400 cu. ft. of air space per man. Rooms, with single beds, are provided for each two men. Each house has a recreation room.

The houses are all single story, sheathed outside with 1-in. rough boards, building paper and bevel siding, and on the inside with wall board, making a very warm building. The partitions also are made of wall board.

The sanitation of the camps necessarily is very complete, because of their being built on the water shed. All toilets are of the chemical type, all drainage from the camps and tunnels being treated with chlorine gas, before being allowed to flow into the natural water course.

The water supply for each camp is obtained from springs or wells.

The food supply in general is furnished by the contractors. The system followed is similar to that used by the army at the various cantonments in this country, the men being fed in clean mess halls, and the board being charged for at cost, not including overhead expenses, so that each man is enabled to get food and lodging at a cost not exceeding $7 a week.

The total number of men employed at any one time will be about 2,000, and the company intends to have a large percentage of this number at work before next spring.

In order that this important link in New York City's water supply system may be completed without delay—the date of completion being. approximately, December, 1924—the contractors have estimated they will require the services of about 1,000 laborers, and 1,000 other able-bodied men, consisting principally of drill runners and helpers, hoist runners and compressor engineers, topmen, muckers and handy men, electricians, mechanics, carpenters, blacksmiths, pumpmen, riggers, motormen, brakemen, and helpers in general. The contractors are prepared to pay 40 ct. to 62½ ct. per hour for labor.

Some of these men can go to work immediately; the balance will be required between now and next spring, by which time the work will be under full headway. It then will be a steady drive for the next five years.

Structural Features and Erection Methods for 258 Ft. High Steel Tower and Tank

Somewhat unusual methods were employed by the Chicago Bridge and Iron Works in erecting a Johnson type differential surge tank at Colton, N. Y., for the Aluminum Co. of America. The structure has a height of 258 ft. from the base of the tower to the top of the shell. The tank itself is 50 ft. in diameter and the cylindrical part of the shell is 56 ft. high. The external riser connecting the bottom of the tank to the pipe line is 12 ft. in diameter and 180 ft. high. The connection of the external riser to the 12-ft. pipe line is made by means of a structurally reinforced steel tee incased in concrete. The tank is supported by eight posts, divided into four sections each, the length of each section being over 50 ft.

The surge feature is obtained by an internal riser which extends from the bottom of the tank to within 3 ft. of the top, a distance of 78 ft. This internal riser communicates with the tank proper by means of suitable differential ports or holes. The action of this tank, in providing proper regulation of the water required by the three 1,100-HP. vertical turbines in the adjacent power house under various conditions of loading, is such that the internal riser pipe is subjected alternately to internal and external pressure of water; that is to say, at certain times water surges up within the riser pipe to its top and spills over and is stored in the main tank when the water level in the main tank is near the bottom of the tank. At other times the water in the riser pipe drops to an elevation near the bottom of tank and the tank itself is full of water. The internal riser is designed for these extreme conditions of loading and its shell is reinforced by heavy angles, spaced approximately 2 ft. centers. From this surge action of the water it can easily be seen that the shell of the tank at times is subjected to an internal vacuum and so the shell plates are reinforced with 10-in., 20-lb. channels to resist a pressure of 15 lb. per square foot. There are also air traps in the roof to aid in overcoming this internal vacuum.

The bottom tower post is designed to carry a load of 1,382,000 lb. and has a section of 105.5 sq. in. This section is made up of two outside flange angles—6 in. x 6 in. x ¾ in., two inside flange angles, 8 in. x 6 in. x ¾ in., two web plates—24 in. x 13/16 in., and one cover plate—34 in. x ⅞ in. The outside of the post is laced with 3½ in. x 3½ in. x ⅜ in. angles.

The top post is designed to carry only 1,150,000 lb. and has a section of 87.5 sq. in. The reduction in section is obtained by using thinner angles and web plates in the top post than is used in the bottom section.

The struts are the box type, built of four angles, 3½ in. x 3½ in. x ⅜ in. and are approximately 21 in. sq. The diagonal tension members in the tower are made up of two rods each, ranging from two 1¾-in. square rods in the bottom panel to two 1½-in. square rods in the top panel. The maximum stress in the rods in the bottom panel is 82,400 lb.

The method of erection of this tank and tower was unusual enough to make it interesting. The external riser was first erected and also the lower half of the internal riser. This portion of the internal riser was used as a mast with the lower end of the boom fastened to the round about angle at the top of the external riser by a special cast steel pivot casting, making a universal joint that allowed the boom to swing from one position to another. The fall line and boom line was connected to blocks at the top of the internal riser. These lines were carried down inside the risers to the hoisting engine on the ground. With this arrangement, the complete tower was erected by moving the boom 180° around the riser only twice. It is interesting to note that the top and bottom sections of the tower weighed over 12 tons each. A special bail was made so that when a section of post was lifted, it would hank at the same level as the tower. This facilitated the landing and bolting up of the tower at the panel points. After the tower was raised the boom was used in raising the tank shell and bottom plates and the internal balcony struts which came at the spring line. With the boom in the position shown in the cut, the fall line was over 2,700 ft. long.

The foregoing matter is taken from The Water Tower, a publication of the Chicago Bridge & Iron Works.

Bucharest-Danube Canal to Be Built

Recent events have impressed upon the Roumanian Government the necessity for a Bucharest-Danube Canal and a commission has been appointed to push the project with all possible speed. The new enterprise will open up all of southern Roumania. This part of the country is practically without any kind of transportation facilities and in noting the many difficulties encountered by the American Red Cross and the Relief Administration in distributing supplies, the Roumanian Government recognized the urgent need for the canal.

The construction of this canal was discussed before the war, but in the strenuous times of the past four years the project was crowded out by more vital things. Building it at this time will not only solve the transportation problem but the labor one as well. It will give employment to hundreds of men who at present are suffering from enforced idleness.

Before the war, a commission composed of delegates from Roumania, Austria-Hungary, and Russia discussed the feasibility of deepening the River Pruth, but the idea was abandoned because of objections raised by the Russian delegates. It was decided that light tugs and barges could be used for transportation and they have been used to some extent by the Americans.

When the distress of the people in Southern Roumania was particularly acute, the American Red Cross workers found serious transportation problems confronting them. The people were in desperate need of supplies, the railroads which hadn't been destroyed were swamped with troop movements, refugees, and supplies, while the camions and even light automobiles were constantly stalled in the muddy roads south of Bucharest. And time saved meant lives saved. The Red Cross was forced to resort to the longer but more certain method of getting its supplies into the typhus and smallpox infested district by sending them on boats from Galatz.

By order of General Vicol, head of the Sanitary Corps of the Roumanian army, the entire resources of the Roumanian army have been placed at the disposal of the Red Cross to assist in the distribution of relief supplies.

No less than 20 military hospitals, released when fighting stopped, have been made centers for a new anti-typhus work carried on by the army, largely with Red Cross supplies. Some of these hospitals, once filled with wounded and sick soldiers, are now caring for hundreds of civilian patients.

Military precision is used in handling the cases, and American inspectors report that their supplies are being used with great care and efficiency.

"The army sanitary corps has shown itself eager to adopt American methods and in applying them has secured remarkable results," said Major George C. Treadwell of the Red Cross, who has just completed an inspection of all relief work of this type in Roumania.

Relief work for people around remote posts and garrisons is being handled directly through the sanitary corps. This has already obviated the necessity of establishing Red Cross centers in many of these out-of-the-way places. Army field kitchen units are carrying relief to numbers of small villages which otherwise could not be readily reached.

With the completion of the new canal, transportation in Southern Roumania will no longer be a question of weeks and months.

Meter Box Houses Curb Cock and Water Meter

A cast iron meter box furnishing a combination housing for curb cock and water meter has been placed on the market by the H. W. Clark Co., Mattoon, Ill. With this box quick and convenient access can be had to the curb cock but the meter can be reached only by the use of the key required to operate the lock of the box lid. The meter box construction is such that it can be readily removed from the concrete walk or pavement without in any manner damaging or defacing the concrete. This is specially advantageous as leaks located back under the walk or pavement may be repaired through the removal of box (by lifting straight up after unlocking lid) and when removed tunneling may be done on either side for a number of feet as may be required to reach and repair leak.

Southland Clark Meter Box.

Results of River Flow Regulation Work of Quebec Streams Commission

Interesting details of the results derived from the storage dams constructed by the Quebec Streams Commission for the regulation of the flow of the St. Maurice and St. Francis Rivers, in the Province of Quebec, are given in the recently issued 7th report of the Commission covering the year 1918. According to the report the results anticipated have been fully realized, both as to profits expected and as to the amount of water available.

The regulation of the St. Maurice River is accomplished by a dam at La Loutre, completed in December, 1917, which creates a reservoir having a capacity of 160 billion cubic feet. The total expenditure has been $2,500,000, of which $1,000,000 is to be paid back to the Government in 30 years by the benefiting companies. Semi-annual installments to cover the interest and sinking funds will be paid by these companies. On the $2,500,000 capital invested the Government receives an annual revenue of $191,000. This amount will be considerably increased when additional water powers on the river are developed. Two water powers on the river have been developed: Shawinigan Falls, head 150 ft., and Grand River Falls, head 75 ft. La Tuque Falls, head 88 ft., is partially developed.

Under natural conditions, the flow of the St. Maurice River at Shawinigan reaches a maximum of 170,000 second feet at the time of the spring floods, and decreases to the minimum of 6,000 second feet during the summer and the winter months. Under regulated conditions the commission guarantees to the plant owners a supply of water sufficient to maintain a minimum flow at Shawinigan not less than 12,000 second feet. The possibility of the water powers at low water periods has therefore been doubled by regulation.

Assuming an efficiency of 80 per cent of the theoretical power, the increase at low water periods at Shawinigan is equivalent to 82,000 HP. This increase, however, takes place for a certain number of days only and it becomes nil when the natural flow reaches 12,000 second feet. This temporary power, when uniformly distributed over the whole year, is equivalent to 32,250 HP.-year. At Grand'-Mère, the benefits are half those recorded at Shawinigan.

It is estimated that the additional power which will result will be 140,000 HP.-year, when all the water-powers on the river are utilized. The construction of the reservoir has increased the possibility of the water-powers by 400,000 HP.

St. Francois River regulation works consist of a dam at the outlet of Lake St. Francois. This was completed in Nov. 1917, and the storage commenced on April 1, 1918.

From the latter date the water in the reservoir was controlled with the gates in the dam. An average discharge of 800 second feet was let out to suit the requirements of the hydro-electric and manufacturing plants located below.

The New Sewage Treatment Plant at Montezuma, Ia.

The town of Montezuma, Ia., on July 27, 1918, began construction of a sewage treatment plant consisting of a sedimentation tank of the Imhoff type, a siphon chamber, two intermittent sand filters and a sludge bed. The operation of the plant marks the end of a long continued nuisance in a small creek where the town has heretofore been discharging its sewage. Mr. J. H. Dunlap, associate professor of hydraulics and sanitary engineering, College of Applied Science, State University of Iowa, has given an interesting account of the design, and construction of this plant in a recent issue of The Transit, from which the following notes have been taken.

The Imhoff tank as designed has a settling period of 2.42 hours based on a flow of 100 gal. per capita from a population of 1,200 or 1.45 hours for a population of 2,000. The gas vent area is 23.6 per cent of the whole superficial area of the tank. The sludge storage capacity up to within 3 in. of the deflecting beam is about 1.67 cu. ft. per capita on a basis of 2,000 population, and up to the slots about 1.88 cu. ft. per capita. The sewage from the town is fresh, domestic sewage readily settleable. Due to the usual failure to remove sludge from the digestion chamber and to keep the gas vent areas free, ample dimensions in this respect were provided. The general dimensions of the tank are 20 ft. diameter, 24 ft. depth to the base of the inverted cone with 5 ft. to the apex. Two 8-in. slots with 8-in. overlaps are provided. The sludge pipe is 8 in. cast iron with a hydraulic head of 5 ft. on the tank outlet. The tank has a hollow tile superstructure, plastered, and provided with a door and windows.

The siphon chamber is of reinforced concrete 32.5 ft. x 26 ft. x 7 ft. inside dimensions. The siphon discharges at a depth of 3 ft. enough sewage to cover one filter bed 3 in. Two 10-in. alternating siphons are used at present with provisions for a third.

Two sand filter beds each having an area of 60 ft. x 150 ft. are provided. On a basis of 200,000 gal. per acre per day, one bed will care for about 400 people.

The sludge bed is 30 ft. x 40 ft. in size.

The contract cost of the plant was $16,100 and the following are some of the unit costs exclusive of overhead and profit, and superintendence. They are based on labor at $4 per day of 10 hours until late fall and after that an 8-hour day, teams at $7 per day of 10 hours, with an 8-hour day later. The length of haul was 1.3 miles.

	Per cu. yd.
Earth work:	
Filter beds, 1,060 cu. yd.	$0.47
Siphon chamber, 187 cu. yd.	.78
Imhoff tank, 408 cu. yd.	.82
Imhoff tank, 408 cu. yd.	2.70
Filter sand, 1,421 cu. yd.	2.78
Filter gravel, 226 cu. yd.	3.59
Concrete 1:2:4, with cement $2.28 per bbl.:	
Imhoff tanks	14.65
Siphon chamber	13.67

Water Works Improvements to Cost $24,750,000 Recommended for Baltimore

Increased water supply for Baltimore, Md., requiring an immediate expenditure of $8,331,000 and an ultimate expenditure of $24 752,000 is recommended by Walter E. Lee, Industrial Engineer, in a report submitted recently to the mayor and board of estimates. The works recommended for immediate construction are as follows:

A dam 120 ft. high with a crest elevation of 520 ft. on the Upper Gunpowder Falls below Prettyboy Branch, impounding 23,000,000,000 gal. of water, all available by simply opening the outlet gates and allowing the water to flow down the river to Loch Raven; the cost of this is estimated at $2,031,000. The construction of an additional mechanical filtration plant of 128,000,000 gal. per day capacity on the west side of Hillen Road, at a total cost of $2,700,000. The construction of an additional 12-ft. tunnel 7.5 miles long through solid rock from Loch Raven to Montebello Filters, to reduce friction losses between these points, at a total cost of $3,600,000.

The improvements to be undertaken at a later date are:

Extension of gravity feeders to low service territory	$5,000,000
New pumping station for increased supply for city and new annex	280,000
Equalizing reservoirs principally for new annex	2,613,000
Lining of existing tunnel from Loch Raven	593,000
Raising existing Loch Raven dam to eliminate pumping	2,641,700
Construction of Deer Creek dam and tunnel to Loch Raven	5,293,500

The improvements it is estimated would provide a supply sufficient for a daily consumption of 200 million gallons.

Personals

J. E. Lucas has been appointed city manager of Yoakum, Tex.

Russell Hosington has been appointed city engineer of Adrian, Mich.

Sidney L. Shonts has been appointed city engineer of Wallace, Idaho.

Homer Anderson has been appointed city civil engineer of Alliance, O.

Lieut. Robert Q. Brown has been appointed acting instructor of civil engineering at the University of Washington.

Samuel P. Flood has been appointed technical assistant to the state reclamation engineer of Texas with office at Austin.

W. D. Salter, formerly city engineer of Boulder, Colo., and later acting city manager, has been appointed city manager.

E. M. Fry, formerly deputy warden of the Oklahoma State Penitentiary, has been appointed city manager of McAlester, Okla.

D. F. McCurrach, chief engineer of the Public Service Commission of Washington, has resigned to accept employment with the North Coast Power Co. at Portland.

Capt. Paul Molitor, who recently returned from overseas service, has resumed his duties as superintendent of the Madison-Chatham, N. J., sewage disposal plant.

C. W. Keniston, until recently with the nitrate division of the War Department, has been appointed as engineer of industrial sanitation of the Industrial Commission of Wisconsin.

E. D. Barstow of the engineering force in the Akron, O., service department, Bureau of Sewers, and formerly city engineer at Cuyahoga Falls, O., has been appointed county sanitary engineer.

H. E. Towle has resigned as vice-president and secretary of the American Water Works & Electric Co. to become a member of the firm of W. G. Souders & Co., Chicago. C. S. Ashdown was elected to succeed Mr. Towle as vice-president, and W. K. Dunbar was appointed secretary.

J. B. Marcellus, formerly drainage and irrigation engineer in the extension department of the Kansas State Agricultural College, has accepted a position as associate professor of civil engineering at the University of Colorado. He will devote two-thirds of his time to the university and one-third to his consulting work.

Industrial Notes

The Franklin Institute, acting through its committee on science and the arts, has awarded its Edward Longstreth medal of merit to John Walter Ledoux of Swarthmore, Pa., for the Simplex Venturi meter manufactured by the Simplex Valve & Meter Co. of Philadelphia.

The Wallace & Tiernan Co., Inc., 349 Broadway, New York City, sole manufacturers of "W. & T." chlorinating apparatus, have recently made a change in their Pacific Coast representative. Their interests at that point will hereafter be taken care of by Alexander Bell with offices at 709 Mechanics Institute building, San Francisco, Cal.

R. C. Sykes, general manager of sales, has resigned his position with the Troy Wagon Works Co., effective Oct. 15, to enter a personal business in which he is one of the controlling partners. Mr. Syke has been succeeded by Ike S. Byrum, who has been with this company for the past eight years as salesman, special representative, and more recently as assistant to Mr. Sykes in the sales work.

The Service Motor Truck Co., Wabash, Ind., has started construction on further additions to its factory. The new unit will be 75x775 ft. in size. The other units of the factories are the same size and this building, together with the new administration building which has just been completed, the factory's garage and cafeteria, will give the company a total floor space of about eight acres.

Railways and Excavation Monthly Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field if subscribed for as a weekly at $3.00 a year; but anyone of the four special monthly issues may be subscribed for as a monthly at $1.00 a year (or any two monthly issues at $1.50 a year) and the 4 special quarterly issues will be sent without extra charge. Three of these special quarterly issues relate entirely to foreign engineering and construction practice and the fourth is our annual "New Equipment Issue." The *articles* in the first two issues of each month (1st and 2nd Wednesdays) completely cover the municipal engineering and contracting field. The *articles* in the first and last issues of each month (1st and 4th Wednesdays) completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and last issues of each month (3rd and 4th Wednesdays) completely cover steam and electric railway location, design and construction. See the "mast head" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials

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"Scared of Everthing"

Under this title the Chicago Tribune denounces the timidity of the house of representatives committee on military affairs. The committee is about to submit a bill for an army but with no provision for universal military service. The Tribune says:

> Gen. Pershing, and every man whose word on military matters is worth the utterance, has told Congress that universal service will be the defense and the method of development for the nation. Congress knows that. The congressmen are convinced. They are merely afraid.
>
> They know that universal service will prevent wars or carry them through successfully. They know that it will strengthen and help the nation. They know that it will not be a burden. They know that its peace benefits alone would be sufficient justification for the adoption of the policy.
>
> It is not a matter of doubt. It is a matter of conviction. But it also is a matter of fear. These congressmen prefer that at some time later young men take chances with their lives rather than themselves now take chances with their jobs.

This is one of the greatest defects of a representative system of government, this fear of the wrath of the voters if anything is done that does not meet with their approval. Unfortunately this sort of fear is not confined to legislators. It is seen even in our courts, at times, and still more frequently in our public service commissions. The desire to be popular is the root of many an unjust decision. Indeed, it is not overstating matters to say that cowardice of the Interstate Commerce Commission is responsible for the bad financial condition of most American railways. Street railways also are in a serious financial condition and the reason is the same—cowardice of public service commissions and city councilmen. The majority of rate making officials have been afraid to raise rates sufficiently to yield an attractive return on the investments in railways and other public utilities, for fear of public outcry. This conclusion is easily deducible from the acts of rate making officials, but anyone who cares to investigate the matter will not find it difficult to secure an admission of this fact from many a public service commissioner. The editor has had several commissioners in different states admit that the fear of losing their jobs had been the underlying reason why commissioners had not acted in accordance with the evidence. In the early days of democracy, a slogan was: "The voice of the people is the voice of God." This form of flattery is as seductive as it is untrue. The voice of the people on ethical matters is nearly, though not always the voice of God; but the voice of the people on economics is usually, though not always, the voice of ignorance.

Because most men are just at heart, we believe that were a popular vote taken that a substantial majority would admit that they are not qualified to pass upon economic measures that are at all intricate, such, for example, as deciding upon fair freight and passenger rates. Moreover, we believe that a majority of men would admit that no

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

man should be allowed to vote on a contested matter in which it is to his personal interest to side with one of the contestants. Now, if these two principles were decided by a majority vote, as we believe they would be, it would follow inevitably that the public would approve the appointment of rate making commissioners and judges by civil service boards, the appointments being for a long term of years, the appointees not to be eligible for any other public office for, say, five years after leaving their judicial positions. Thus would be secured the impartial attitude requisite for fair decisions; and under proper civil service tests there would also be secured the technical experience and knowledge that such commissioners and judges need, yet at present usually lack.

We have used rate-making officials merely as an illustration. What is true of one class of economic problems that affect the general welfare is true of every class. Tariffs and other taxes should not be decided by politicians holding office through election, for taxation problems not only involve highly complex economic data but require for their fair solution a judicial attitude. Neither technical knowledge nor judicial attitude is found in the average legislator, nor will it ever be found there in high degree so long as legislators are elected by popular vote. When Mr. Taft was president he urged the employment of a permanent non-partisan tariff commission, not only because he saw clearly the inability of the average congressman to decide tariff questions properly, but because he saw that log-rolling compromises are inevitable where there is a clashing of divergent interests of different sections of the country.

As the Chicago Tribune truly says, congressmen are "scared of everything," to which may be added that most daily papers are almost as timorous as congressmen, and for the same reason. It is not regarded by American editors as being popular to tell American voters that they should have no direct voice in deciding certain economic matters. We believe, however, that the average voter already knows that he is incompetent to decide most economic questions, and that he can easily be shown that it is in his interest to have competent, impartial men make the decisions. In short, there is no sound reason why editors of daily newspapers should not oppose "initiative and referendum laws" that make the public vote upon measures that they are too busy to investigate properly and upon which they are not sufficiently expert to render a correct decision even if they had time for investigation.

The other day the voters of Chicago voted on more than half a dozen important economic measures—or rather they had the chance to vote, but fewer than one-third of the registered voters, cast a ballot. Newspapers treat such negligence as if it were reprehensible, but is it? Which is really reprehensible, voting on a question of which you are necessarily ignorant, or refusing to vote under such conditions? When a scientific man is asked to express an opinion on a scientific matter outside his specialty, he usually declines to do so; yet who has ever regarded such silence as anything else than a proof of true wisdom and a laudable act? Give the silent two-thirds of the voters in Chicago credit for having common sense, and there is neither mystery in their silence nor cause for editorial tirades against it. Among the measures that the voters were asked to decide upon were several large bond issues, the merit of not one of which the average voter could determine as would a civil engineer, for example. Then there was a question relative to "municipal ownership," one of the most debated of questions, yet wholly a question of economics and one that is still debated merely because the average debater has not studied the statistical results of municipal ownership. Still two-thirds of one-third of the voters of Chicago, or about 20 per cent of all the voters decided in favor of "municipal ownership," without having any real knowledge of the subject at all! Who are the reprehensible ones, then, in this election? Those who are ignorant and admit it by refusing to vote? Or those, who are equally ignorant, yet anxious to express an opinion?

We are of those that have faith in the common sense of American voters, and our faith is sufficient to warrant the expectation that they will not resent being told that they have no right to vote on many an economic matter; no more right than they would have to vote on the methods of conducting a battle or even a skirmish.

"Rules Are Made to Be Broken"

"Rules are made to be broken." This was what the president of a great manufacturing company told one of his department heads who failed to do a desirable thing because there was a rule that stood in his way. Of course, in such a case, the rule should not be broken without securing the authority to do so, but this department head had not even asked for authority to break a rule that he knew to be objectionable in certain cases.

Every executive lays down certain rules of conduct, but it is only a good executive that is quick to revise, modify or event annul a rule that hampers economic performance. By this test, how many of us can invariably qualify as being good executives? Probably no one, for who of us can always escape the bondage of habit?

Most offices in large cities have a rule to the effect that "no soliciting of employes by agents or salesmen is permitted during office hours." The rule is undeniably good, provided it is breakable upon certain occasions. It was this rule that caused a considerable amount of trouble during the war when Liberty bond salesmen were denied access to office employes on the ground that it was against the rules of the office to permit solicitation of any kind for any purpose. Here, however, the feeling of patriotism was so strong that the "rule" was eventually broken in the vast majority of instances; and when permission could not be secured to break it, the suspicion arose that the head of the firm was pro-German.

After this long preamble, may we be pardoned for suggesting that when the head of an engineering office refuses to permit the solicitation of subscriptions for any engineering periodical, he is either thoughtless or he is pro-Ignorance? The subscription solicitors of Engineering and Contracting occasionally encounter this sort of engineering executive—a man ruled by rules, often of his own making. When asked his reason for not permitting his employes to be interviewed, his reply usually is: "It is against the rules. If we permit you to solicit, how can we, in justice, refuse others? Besides, our men are very busy. Consider the lost time, taken in the aggregate, resulting from even one solicitation of all our men. Moreover, why don't you see them at their homes?"

It seems to us that each and every one of these objections lacks economic merit. We say economic merit, for, after all, this is an economic matter. If it can be shown that the time lost by the employes during subscription solicitations is more than offset by their increased efficiency as a result of their reading engineering periodicals, it follows that the general rule against solicitation has a justifiable exception. And what engineer doubts that technical efficiency is so markedly increased by technical reading that the immediate time lost in listening to subscription solictations is as nothing compared with the ultimate gains?

The fundamental trouble is that executives who insist upon the enforcement of a general rule against the soliciting of office employes, have lost sight of the fact that the original reason for making the rule was purely an economic reason—the securing of high efficiency of employes. When it can be shown that the rule results in a lower efficiency than would be secured if it were broken, then it should unquestionably be broken; and it would be broken were it the habit of the executive always to look behind the rule to the reason that originally led to its adoption. But this is precisely what a mediocre executive seldom does, and what a superior executive occasionally fails to do.

As for the suggestion that office employes be solicited at their homes, of course it would seldom be made by an executive acquainted with the high cost of individual solicitation where the individuals are widely scattered. This again is an economic matter, and it is one that the engineering executive can readily appreciate once it is pointed out.

Occasionally enginering colleges refuse to break their general rule against the solicitation of students, and for the same reasons that are given above. Here the case is even more clear cut, for the students are attending college not only to learn but to form reading habits that will lead them to continue to learn after graduation. Sometimes the educator replies: "I grant that, but I myself urge the students to subscribe for at least one engineering periodical. Moreover, you can appoint one of the students as your subscription agent."

If the educator were himself an experienced salesman, he would never suggest the substitution of an amateur for a professional salesman. He would know that for every subscription that he or one of his students might sell, a professional subscription solicitor would sell five to ten. But he does not know this—until he is told, and then he is apt to doubt it. Good professional salesmen not only have the inborn talent of the successful propagandist or promoter, but they are practical psychologists. Let no engineer make the mistake of thinking that merely because he knows a great deal about a given thing, therefore he can sell that thing successfully. Good salesmen are "born and then made," just as are the members of any other profession. There are many books, and at least four excellent magazines on the science and art of salesmanship. How many articles and books on salesmanship have you read? If few or none, then do not suggest amateur salesmanship when professional salesmanship is available, for it is an economic mistake to do so.

In no carping spirit is this article written, for we realize that "to err is human" and that none of us escapes making many a mistake.

"The Problem Is Not One That Engineering Training Fits an Engineer to Understand"

Every little while some political economist or lawyer asserts that a certain economic problem is too deep for the comprehension of engineers, and, inferentially, not too deep for the one who criticises them. Thus in a 32-page pamphlet on "Theoretical Depreciation," we are told by its author, George N. Webster, of 60 Wall St., New York City, that:

> There are many engineers of honest intention who pretend, or even think, they have knowledge of this subject, who while competent in the ordinary branches of construction engineering are utterly lacking in a real and fundamental understanding of this dangerous fallacy of "theoretical depreciation."
>
> The problem is, in fact, not one of engineering nor is it one that engineering training fits an engineer to properly understand. The same may be said of the accountant and his training. The subject is one primarily of applied economics and must be studied from the standpoint of the mutual economic interests of the consumer and the investor.

Mr. Webster undertakes to prove that all accrued depreciation is "theoretical," and with him it is evident that what is "theoretical" is purely imaginary, hence unworthy of consideration in establishing a rate making "value." That this reasoning is false may be easily shown by establishing the fact that a true "theory" is always in accord with the facts. That public utility and railway property depreciates can not be denied, nor can it be denied that some theory is always needed to explain the nature and extent of the accrued depreciation.

It is true that rates of charge for service should be independent of the accrued depreciation of the plant that renders the service; but Mr. Webster seeks to establish this truth by reasoning that is utterly fallacious. And, in order to do so, he regards it as imperative first to deny to engineers the right to express an expert opinion on the subject. Then in order to sustain his position he brands his opponents among engineers as "professional depreciators," "confiscators of property" and "assassins of value." The editor is not among these "assassins," and feels no personal resentment at this intemperate language, but he does resent the statement that depreciation involves any problems that are beyond the pale of engineering judgment.

An engineer is one whose profession it is to apply science in solving problems in economic service or production. Not only do engineers assert this to be their function, but they prove it by their acts and their writings. In the bibliography on appraisals and rate making issued by the American Society of Civil Engineers, about 1,000 references to articles and books are given, the vast majority of which were written by engineers. More than half of these articles contain discussions of depreciation, and in them will be found the essence of all that Mr. Webster has urged against "theoretical depreciation," in addition to a vast deal that he has seemingly never heard or dreamed of hearing.

Only a few years ago (see Engineering and Contracting, Mar. 31, 1915) John R. Commons, professor of "economics" of the University of Wisconsin, testified before a congressional committee to the effect that "engineers' ideas on value are muddled." He undertook to show that engineers have such narrow conceptions of values and social relations that they are unfit to render the final decision as to what a "rate making value" should be. At that time we showed that Prof. Commons was the one whose ideas of "values" were confused, for when he was talking of "rate making value" he really meant "investment" or "original cost." We also pointed out that this entire question had been thrashed out in the engineering press several years before Prof. Commons had entered his self-made arena of controversy. We mentioned in particular an article on this subject published in Engineering and Contracting, Dec. 11, 1912. That article is now 7 years old and will bear reprinting, so we give it on another page, under the title of "Two Conflicting Theories of Valuation."

There are certain people who, after long residence in a realm of pure speculation, come not only to regard practitioners with a certain lofty condescention, but imagine that a practitioner knows little or nothing beside the use of his tools and his data. It so happens, however, that scientific practitioners are not only skilled in their practice but well informed in the theory upon which that practice is based. Such, pre-eminently, is the engineer. To him a theory is more than a speculation; it is an explanation that really explains. For example, the theory of gravitation explains quantitatively certain interactions of masses; the theory of elasticity explains quantitatively certain stresses and strains. Working daily with such theories, the engineer necessarily becomes habituated to seek for theories—this is for cause-effect explanations—to guide him in everything he undertakes to do. Is he given the task of appraising a property for rate-making purposes? Then he studies all the printed theories not only of valuation and rate making, but of political economy, in so far as they bear upon his problem. And, if he has originality, he seeks to perfect any theory that is crude, or to produce a new theory where the existing one is false. He works with theories, and he can not afford to work with those that are incomplete or false; whereas, the average teacher of political economy merely teaches theories that he has read, usually in a somewhat narrow field. Unable to strike a trial balance in a ledger, most political economists fancy themselves competent to lecture practicing engineers on their ignorance of economics!

We do not contend that political economists can teach engineers nothing. What we do contend is that engineers are practicing economics, based on theories, and that their practice leads them to a more profound understanding of economic theories than normally is to be found among political economists who never practice what they preach. We go further, and assert that it will be engineers and not political economists who will eventually solve the problems of economic government. Already we see the shadow of that coming event, in the fact that most of the managers of cities under "city manager government" are engineers.

Highway Departments Urged to Award Contracts During the Winter

A good many railroad contractors have been entering the road contracting field, partly because of the scarcity of railroad construction jobs and partly because road contracts are larger, on the average, than they have been in the past. The Bates & Rogers Construction Co., of Chicago, recently secured an $826,000 state road contract in Ohio. A few years ago a road contract of one-tenth that size would have been regarded as being "large."

Large contracts usually justify the purchase of large construction plants, provided the plants can be kept busy a large part of the year for several years in succession. This proviso is very important. Hitherto the general practice of splitting road construction into relatively small jobs has not only prevented the purchase of large construction plants but has attracted a swarm of small contractors, most of whom were relatively inexperienced business men. The result has been "a new crop of inexperienced contractors" every year in the highway field, for no sooner had last year's "crop" acquired some knowledge than the new "crop" crowded them aside by bidding below cost.

To attract large contracting companies, every effort should be made to award highway contracts in the winter. Thomas H. MacDonald, Chief of the Bureau of Public Roads, has just written a letter to all state highway departments urging them "to place under contract during December and January as great a mileage of roads as possible. In that letter, which will be printed in full in our issue of Dec. 3, Mr. MacDonald points out the desirability of storing road materials in stock piles, during the winter and spring months, for, by so doing, not only will quarry and pit plants be kept busy a greater percentage of the year, but enough open top freight cars will be available for hauling the materials. To this excellent advice we wish to add the advice to make each contract as large as practicable.

Book Reviews

Topographic Stadia Surveying—A Manual with Reduction Tables and a New Type of Reduction Diagram.—By C. E. Grunsky, Eng. D. New York: D. Van Nostrand Co. Leather; 4½x7 ins.; pp. 95; illustrated. $2.00.

Reviewed by H. J. ARMSTRONG,
Associate Professor of Railway Engineering, Armour Institute of Technology.

In this compact little volume the author has covered very thoroughly this branch of surveying and has drawn upon his extended experience in recommending various departures from what the ordinary text-books on surveying have practically standardized.

The particular type of stadia rod illustrated adds one more to the great number already proposed or in use, and the author very good naturedly remarks that "no one will be surprised or misled" at the statement that he has found this one to be the best for general use.

An interesting description of the Porro telescope, unheard of by the majority of surveyors, occupies several pages, and it is shown that notwithstanding the desirability of a telescope which would eliminate the "f + c," the invention of Mr. Porro in 1823 has not been made use of on account of various mechanical difficulties.

The liberal use of the magnetic needle is recommended, as is also a method of procedure whereby the height of instrument above the station plug is eliminated from the notes.

The ordinary stadia reduction tables are given and also Anderson's tables, in use by the U. S. Geological Survey. A specially constructed diagram about 14x18 in. is tucked in a cover pocket.

Technic of Surveying Instruments and Methods.—By W. L. Webb, C. E., and J. C. L Fish, C. E. New York: John Wiley & Sons. Flexible cover; 4x7 ins.; pp. 317; illustrated. $2.00.

Reviewed by H. J. ARMSTRONG,
Associate Professor of Railway Engineering, Armour Institute of Technology.

These well-known authors have collaborated to produce a book which deserves a place in the library of any civil engineering student or teacher of surveying, not because it replaces any general text on surveying but, according to the preface, because it is intended to supplement the general directions of a general text by detailed directions for specific operations in field and office. "The aim has been to make detailed directions so complete that the student can go through the routine of the exercises without verbal instructions; so that the instructor may be free to watch carefully the performance of each student, and give advice, etc." While intended primarily as an instruction guide for student field work in surveying, it is believed that this little book may be of service to the practicing surveyor in enabling him to pick up quickly standard methods of approaching unfamiliar surveying problems.

Inter-Professional Conference at Detroit.—With the purpose of bringing together the professional men of the country in order to plan more effective relations and act together on matters pertaining to the public good, an Inter-professional Conference is being called to meet in Detroit, Nov. 28 and 29. The conference was suggested by the Post-War Committee of the American Institute of Architects, which was established to study the new obligations thrust upon the architectural profession by the war. The subjects which might well come before such an inter-professional organization have been classified under three heads: (a) The functions and inter-relations of professional organizations. (b) Relations of professions to the public. (c) Educational obligations of the professions. The office of the organizing committee of the Inter-professional Conference is at 56 W. 45th St., New York. The meeting in Detroit will be held at the Hotel Statler.

Two Conflicting Theories of "Valuation" of Railways and Utilities

By HALBERT P. GILLETTE, Editor.

After floundering several years in a morass of conflicting court and commission decisions relative to "rate making values," I decided to try to bring some order out of the existing confusion. Back of the conflicting decisions might there not be two or more tacit "theories" that actuated the courts and commissions? No court or commission had, up to that time (1912), laid down any definite theory of "valuation." The Supreme Court had not (nor has it yet) reversed its decision in the Smyth vs. Ames case, in which it held that to arrive at a rate-making value, consideration should be given to: (1) The original cost of the property, (2) the market value of the stocks and bonds, (3) the cost of reproduction, (4) the depreciated value, and (5) the gross and net revenues. In addition, the court had said, there might be other elements of "value" to be weighed in arriving at the "rate-making value." To an engineer this enumeration of "elements of value" was not satisfactory. By what process of mental necromancy could an "original cost" be combined with the "market value" of securities, to give a "rate making value"? I could not see, so I decided to make a search for the unstated principles that led to conflicting court decisions.

To begin with, I tabulated all the leading court and commission decisions on disputed points relating to "value." Then I read the reasons given for each decision. By this systematic search, I was soon able to see that a great many decisions rested upon the tacit assumption that a public utility is an "agent" entitled to be recouped for his expenditures in behalf of his "principal," the public. So I formulated the theory definitely, and I coined the term "agency theory" to cover it. On the other hand, there were many decisions that were evidently based on the assumption that public utilities were not "agents," at least in a broad sense of the term, but, like other companies and individuals engaged in business, were subject to the law of supply and demand. In this case their rates of charge for products or services were regulated by competition, existant or potential. Hence the "value" of their property was "market value." So I termed decisions that accorded with this conception as being rendered under the "competitive theory."

In Engineering and Contracting, Dec. 11, 1912, I published my first article on this subject under the title, "Two Conflicting Theories of Valuation of Public Service Companies." Although that was seven years ago, and in spite of extensive published quotations from that article, not a few engineers are still reasoning illogically about "rate-making values" because they do not realize that there are two distinct theories that govern every rate-making decision, even where no theory is definitely announced by the judges. The courts themselves are still floundering because of the same lack of perception. Accordingly it seems wise to publish again the entire article as it appeared in Engineering and Contracting, Dec. 11, 1912, but with the following addenda.

Prior to the war, although prices and wages had been rising, there had not been a rise sufficiently spectacular to make it clear that an investor in public utility property might suffer a great loss were his interest calculated on the money invested. In justice, a true agent should not be compelled to accept any loss not due to his own acts. But if, following his investment, the general level of prices and wages rises, say, 100 per cent, it is obvious that an investor in public utility property will virtually suffer a loss of 50 per cent of his investment if he receives only a "fair return rate" (say, 6 to 8 per cent) on his original investment; for the purchasing power of his interest money will be just half what it was at the time of making his investment.

If it is contended that all investors run similar risks from depreciated currency, it should be remembered that, on the contrary, other classes of investors are not restricted to a limited "fair return rate." Farmers, for example, raise the price of their products and correspondingly increase the value of their farms when the currency becomes inflated. Owners of buildings and plants of all kinds do the same, until ultimately they secure returns that yield them normal profit rate on the cost of reproduction of their property new—not on its actual cost.

I believe, therefore, that justice demands, and economic forces will ultimately secure, for investors in railways and public utilities at least a "fair return" on their original investment multiplied by a price-change factor. This price change factor will be the ratio between the average "price index" as of the time the investment was made and the "price index" as of the time of the fixing of rates. This result would be approximated in most cases, but by not always using present construction prices and wages as applied to work done under the original conditions.

With the foregoing evolution of the agency conception in mind, the following statements (first printed in 1912) still express my opinions on railway and public utility "valuations" for rate making purposes:

TWO CONFLICTING THEORIES OF VALUATION OF PUBLIC SERVICE COMPANIES.

Much of the diversity of opinion as to the "value" of public utility property is explained when it is recognized that there are usually two diametrically opposed theories underlying the appraisals made by those who differ. Even skilled appraisers are themselves frequently unaware of the fact that there are two theories, as as evidenced by the frequency with which they mingle the two theories in one appraisal.

A science cannot reach a high state of development until theories are evolved. Hence the science of valuation must needs remain rather embryonic until correct theories are available for application to appraisal problems.

No one who has given much thought to appraisals can fail to have reached the conclusion that the object of the appraisal must be known before the problem can be correctly solved. If the object is rate regulation, we have still to consider the fundamental theories of rate regulation before we can safely attack all the appraisal problems. There can be only three theories of rate regulation, which the writer prefers to designate by the following terms:

(1) Competitive Theory.
(2) The Agency Theory.
(3) The Combined Agency and Competitive Theory.

The Competitive Theory.—Under this theory the rates of a public service company are assumed to be regulated by the law of supply and demand acting under competitive conditions. This does not imply that there shall be actual competition. The competition may simply be potential, as when a shipper of freight by rail may be free to ship by water, or as when a user of electricity for light may be free to use gas or kerosene. Competition is still potential, and often of enormous force, even where there is no substitute for a given service in a given locality, for the user may move to another locality where lower rates prevail. There is also the potential competition of other companies who may come into an existing field where rates are high. Finally there is often severe competition for the markets of the country, as when the lumber of Oregon and Washington competes with the pine of the South, thus affecting freight rates of railways serving those districts.

In the competition of different things and of different markets—potential as well as actual—we have had a powerful and automatic regulator of rates. The potency of such competition has been far greater than is commonly believed. But this is not a subject pertinent to the present discussion. It suffices to call attention to the fact that the competitive theory of rate regulation has been, until very recent years; the predominating theory in America And its past influence upon our minds has been so great that only by an effort can we free ourselves from its coerciveness when we approach problems of rate-making based upon a theory that is wholly different.

The Agency Theory.—According to this theory of rate regulation, every public service company is an agent of the public, delegated to perform certain services and to collect payment therefor. Webster defines an agent thus:

"One who acts for, or in the place of, another, by authority from him; one intrusted with the business of another."

Because a public service company is regarded as an agent, it may exercise the power of eminent domain, it may be required to make a periodic accounting of its stewardship, it may be required to limit its rates of charge for service, it may be protected against competition, it may be required to act in harmony with other public agents. It is always subject to control and to protection.

The Combined Agency and Competitive Theory.—According to this theory, an attempt is made to regulate rates in part by competition and in part by direct control. This is the present theory—a mongrel growth that marks the evolution from the competitive theory to the agency theory.

Valuations Based on the Different Theories of Rate Regulation. Every appraiser must adopt one of the three theories of rate regulation, whether he does so consciously or unconsciously. If he adopts the competitive theory of rate regulation, then a public service property is worth only what it will earn. In brief, its total value is its capitalized present net earnings plus or minus the present worth of any increment or loss in future annual net earnings. This is commonly called the "commercial value" of a property; and there are those who stoutly contend there is no other value. If we grant their tacit premise that competition is the only rate regulation, we must grant their conclusion that a property is worth what it will earn. But the moment we deny their premise, their conclusion is destoyed.

If the appraiser adopts the "agency theory," the value that he seeks is the investment value, or more briefly, the investment or actual cost. An agent is certainly entitled to be recouped for all investments made in behalf of his principal. And it is equally certain that he is not entitled to receive payment for "values" not represented by actual outlay of capital on his part. Thus, if an agent buys copper at 15 ct. per pound and if it subsequently rises to 20 ct. the principal and not the agent should be the gainer by the increment in value.

In brief, then, the "agency theory" commits an appraiser to the policy of ascertaining the actual investment made by the agent, which investment is the "value" for rate-making purposes. In such cases an appraiser follows what may be called the historical method of estimating the cost of reproduction of the property. He seeks to ascertain exactly what the public service company did to construct the given plant, and he estimates what it would reasonably have expended to create the plant and to develop its existing business. He checks his estimate against the available accounting records, or vice versa.

The appraiser who follows the agency theory is concerned with the past. His criteria are weighted average prices of preceding years and the accumulated deficits in fair return.

On the other hand, the appraiser who follows the competitive theory is concerned only with the present and the future. His criteria of value are present prices and present net earnings modified by the prospects of future change.

Having briefly stated the radical difference in these two theories, let us tabulate some of the more important appraisal corollaries that flow from each theory:

Agency Theory.	Competitive Theory.
1. Piece-meal prices allowed for piece-meal construction.	1. Only wholesale prices allowed for extensive work.
2. Weighted average prices of past years allowed.	2. Present prices, or those that may be expected in the immediate future, are used.
3. All work actually done by the company is appraised; e. g.: (a) Clearing rights of way as they existed at the time of construction. (b) Taking up and relaying pavement in streets where it was actually done. (c) No allowance for increased value of a "seasoned roadbed" where nature has effected the solidification. (d) Pioneer surveys and other expenses necessarily incurred in pioneer days allowed.	3 Only that work that would need to be done today to produce an equivalent plant is appraised, e. g.: (a) Clearing rights of way as they exist now. (b) Taking up and relaying pavements necessary to duplicate the plant today. (c) Allowance for "seasoning" regardless of its cause or actual cost. (d) No allowance for pioneer costs now that pioneer conditions no longer exist.
4. Development cost calculated by ascertaining the actual residual deficits in fair return.	4 Franchise value calculated by capitalizing the annual net profits that may reasonably be expected.
5. No allowance for increment in values for land purchased for rights of way.	5. Allowance for all increments in land values.
6. No allowance for investments in property now in use, or for losses in economic value.	6. No allowance for investments in property not now in use, nor for losses in economic value.

We might enumerate many other appraisal divergencies that occur in consequence of the two divergent theories of rate regulation, but the foregoing will suffice to make clear not only the fundamental difference of the two theories but also the rarity with which either theory is completely followed by appraisers, by commissions or by courts.

The writer maintains that, before we can ever emerge from the present jungle of contradictions in public utility appraisals, we must not only recognize the existence of these two theories, but we must decide exactly to what extent the one or the other theory shall be adopted. Possibly for the present we must continue to use a combination of the two theories, in order to tide over the present transitional period of rate regulation; but ultimately we must adopt the agency theory in its entirety, for we cannot continue to subject public service companies to strict control without giving them perfect protection from competition of all sorts. The rise or fall of prices paid for materials or labor is itself the effect of competition of one sort or another, and such a change in prices is beyond the control of the agents of the public—i. e., the public service companies. How preposterous, under the "agency theory," it is to appraise a public utility during an era of low prices, such as we have just experienced, and to apply those low prices to materials that were actually purchased during normal years.

Yet this result is precisely what is prescribed by the public service laws of certain states and even by a decision of the supreme court. Equally preposterous, under the "agency theory," is to apply wholesale prices to a plant that was necessarily built piecemeal. Nor is it one whit less objectionable to go to the other extreme and pay a public service company for the taking up and laying of a pavement that did not exist when the company built its plant. All these are preposterous appraisal acts, if the "agency theory" is adopted as sound.

Subconsiously certain appraisers and certain important commissions have been working toward the "agency theory" of appraisals, for if we study their findings we see that the findings correspond with nearly all the conditions above tabulated under the Agency Theory. In fact the Wisconsin Railroad Commission may be fairly said to have come to almost complete adoption of the "agency theory" of appraisal. It did not reach this position at one stroke, nor has it apparently realized fully whither its decisions were trending. In the early appraisals of the steam railways of Wisconsin we find, for example, no development costs or "going value" allowed. The "agency theory" had not carried the commission that far at that time. The writer mentions this fact in no spirit of criticism, for in his appraisal of the railways of the state of Washington the writer was by no means consistent with the agency theory, although the writer was careful to secure and present to the Railroad Commission the actual costs of construction and equipment, so that in this way, the Commission really had before them an appraisal based on the agency theory, as well as the cost of reproduction.

It would seem that some appraisers have fancied that a value for rate-making is a sort of composite picture of "actual cost," "cost of reproduction," "present value" and "market value of stocks and bonds." The writer is at a loss to find any logical relation between these four things. They certainly are not factors whose combination can be made to yield a correct answer to the appraisal problem. The "actual cost" is, in fact, an appraised value arrived at according to the "agency theory"; whereas the "market value of stocks and bonds" is an appraised value arrived at according to the "competitive theory." Hence we have two distinctly antagonistic "values," and not two that may be blended to produce a value for rate-making purposes.

There Can Be but One Value for Rate-Making Purposes and It Must Be Based Upon Some Well Defined Theory.—This is the conclusion toward which the science of rate regulation has been slowly trending. It seems to the writer inevitable that the agency theory will eventually be adopted in its entirety for the appraisal of public service property created in the future. In other words, the actual cost of the property, including the accumulated deficits in fair return, will be the "rate-making value." Even increments in land value will be regarded as profits; that is, as part of the fair return. This is for future expenditures when public service company expenditures will be carefully scrutinized; that is, when the principal (the public) will carefully watch its agent (the public service company).

But what of the past? Upon what theory shall we base our appraisals of public service company property that has been built during an era of competition? Shall we apply the newly adopted "agency theory" to property that was built and operated upon a "competitive theory" basis? These are difficult questions to answer, quite as difficult, in their way, as was the slavery question. When a newly evolved code of morals made it reprehensible to own slaves, there were many who advocated freeing the slaves without giving compensation to their owners. It would have been more just had the general public been taxed to purchase freedom for the slaves, and it would also have been more economic than the war that made them free. Similarly, if it now seems unfair to have permitted public service companies to have capitalized their profits, we should realize that this is a new point of view—so new that we will see no injustice in permitting private companies to do the very same thing ad libitum. May it not, therefore, be both just and, in the end, a matter of public economy to appraise the franchise values of existing public service companies by capitalizing their net profits? The early decisions of courts all leaned in that direction, and a very recent decision of an important public service commission is distinctly in favor of capitalizing net earnings to ascertain total values of public utilities.

Certain it is that the capitalized net earnings of one class of public service property have been almost universally recognized as being a "fair value," namely the capitalized earnings from land and land entities (like water) owned by public service companies. All land values are based on capitalized land rentals, and appraisers are a unit in conceding that public service companies are entitled to the "unearned increment" on their land. Why, then, should they deny the companies the right to possess the earned increment on their business? In other words, why should land rentals be capitalized (which is essentially what is done in appraising land at its present value) while other profits are excluded from capitalization? The only logical answer to this question is that the "competitive theory" still holds as to land, whereas the "agency theory" has partly displaced the "competitive theory" as to the other property of public service companies. This is tantamount to the adoption of a mongrel theory that is a mixture of the two theories and for which there is really no logical defense except that it is expedient to compromise.

In view of the relative novelty of the "agency theory," insofar at least as its actual application to public service companies is concerned, is it not more logical and fairer to apply the "competitive theory" in its entirety to public service company property that has been created prior to the general adoption of the "agency theory"? In other words, should not the present "commercial value" of the property of public service companies, including all capitalized profits, be regarded as belonging rightfully to the owners of the companies? In brief, should not the "competitive theory" be applied in appraisals of existing public utility property?

On the other hand, should not the "agency theory" be applied in its entirety to all future relations between the public and the public service companies? An appraiser of public utility property hereafter created would then seek merely the actual investment in the plant plus deficits in fair return—the development cost.

Such a procedure would involve no incongrous mingling of two theories of valuation, and, in the writer's opinion, it would be the just thing to do.

Those who have written and talked on the subject of appraisals have often started their discourse with a definition of the term "value." But they seem rarely to have perceived that the definition of "value" rests upon one of two theories, which theories should themselves be defined. "Market value" rests on one theory; "investment value" rests on another theory. The first is predicated upon competitive conditions, the second upon agency conditons. It has seemed to the writer that these two theories should be the very first things to consider before any definitions of "value" are adopted, and before an appraisal for rate-making is even begun.

French Rebuilding Railways.—Rapid progress has been made in repair and reconstruction of railways in northern France, destroyed by the Germans during the retreat or in the course of war. Of the 20,000 miles of track found destroyed at the time of the armistice practically all had been rebuilt by Nov. 1 and service re-established. The work included the rebuilding of 1,180 bridges and the reconstruction in whole or in part of more than 350 railroad stations.

Time Tests in Relaying 105-lb. Rail

In connection with the relaying of 104 pieces of 105-lb., 33-ft. new rail in the yards of the Michigan Central R. R. at Jackson, Mich., on March 2, 1917, several tests were made of different operations to determine the average amount of time used and lost during a day's work on this kind of construction. On the day this work was done the weather was clear and cold with a temperature of + 12° F.

The force engaged was as follows:

	Total daily cost.
1 foreman drilling at $87.50	$3.40*
1 assistant foreman at $75	2.90*
1 timekeeper at $75	2.90*
2 cooks at $2	4.00
40 laborers at $2	80.00
1 water boy at $2	2.00
2 men drilling at $2.50	5.00
1 man wiring at $2.25	2.25
Total daily cost	$102.45

*On the basis of 26 working days per month. It should be borne in mind, however, that the men on a monthly scale receive pay regardless of whether or not the rest of the gang is working.

The men drilling and wiring were engaged in bonding. With the exception of this bonding crew and the timekeeper, the entire labor force were Turks.

The material used in the work was as follows:

104 pieces of 105-lb., 33-ft. new rail.
103 pieces of 105-lb., 38-in. angle splices.
4 kegs of track spikes.
624 bolts with nuts.
212 pieces of 52-in. copper plated bonding wires.
424 pieces copper plated bonding lugs.
1 pair 105-lb. continuous insulated joint.
2,580 wooden tie plugs.

The labor force left the bunk houses at 6 a. m., on hand cars for Jackson Yards, 3 miles distant. They arrived at the yards at 6:20 a. m. Unloading hand cars and preparing for work took from 6:20 a. m. to 7:00 a. m. From the latter hour to 12:30 they were engaged in laying rail. The dinner hour was from 12:30 to 1:30 and from 1:30 to 5:00 the gang worked relaying rail. They left the yards for the bunk houses at 5 p. m., arriving there at 6 p. m. The above time includes delays from various causes but does not include the time taken for cutting bolts and taking apart old rail.

Waiting for material to be distributed along the track and for a train to pass so track could be broken made 22 laborers idle from 7 a. m. to 7:30 a. m., and 36 laborers from 7:30 a. m. to 7:50 a. m. Breaking and closing track for continuous traffic amounted to 3 hours for the various trains. While this operation does not make the men idle, it delays the progress of the work. The men are kept busy spiking and fastening the rail which had not been completely finished as the work proceeded. An accident to one of the men caused the gang to be idle for 10 minutes.

The time tests of the various operations gave the following results:

Driving Spikes.—It took one man 15 minutes to drive 20 spikes. With a unit of one spike for the same man the following time was used for each spike drive: 1 minute; 45 seconds; 30 seconds; 30 seconds; 25 seconds; 30 seconds; 15 seconds; 30 seconds.

Bonding.—One man drilling four holes in each 105-lb. rail with drilling machine:

Start.	Finish.	To next joint at
9:50:00	9:54:15	9:54:50
9:55:05	10:00:45	10:01:25
10:01:25	10:05:50	10:06:25
10:06:30	10:10:50	10:11:30
10:11:55	10:15:50	

With one man wiring and two men bonding wires to each joint the following records were obtained:

Time from start to finish.	Time to move to next joint.
1 min., 00 sec.	10 sec.
1 min., 15 sec.	12 sec.
1 min., 18 sec.	15 sec.
1 min., 20 sec.	10 sec.
1 min., 50 sec.	20 sec.
1 min., 20 sec.	10 sec.
1 min., 19 sec.	12 sec.

In addition to this 15 minutes were used to bend 125 bonding wires at one end and distribute them over 2,000 ft. of track.

Pulling Spikes.—One test showed that 18 laborers pulled 700 spikes, in a distance of 1,155 ft., in 30 minutes. At a unit of one 33-ft. rail length, 20 ties to the rail, spikes pulled on both sides of one rail only, it took 7 laborers 12 minutes to pull the 40 spikes. At a unit of one man for 20 spikes (one side of 33-ft. rail) the two records varied greatly as will be seen from the following table:

	Time.
1st man	14 min.
2nd man	3 min.
3rd man	3 min., 30 sec.
4th man	6 min. 25 sec.
5th man	5 min., 20 sec.
6th man	3 min., 50 sec.

Lifting Old Rail and Throwing Off Ties.—Four laborers handled 254 ft. in 14 minutes, and 3 laborers handled 990 ft. in 43 minutes. These entire lengths were in one piece, and on one side of the tracks the rail was lifted over the outside line of spikes, as these were left in to set and line new rail.

Plugging Old Spike Holes and Adzing Ties.—In this work 7 laborers covered 264 ft. in 25 minutes; and 9 laborers covered 990 ft. in 50 minutes. This includes sweeping and removing dirt from the ties.

Placing New Rail.—Ten laborers placed 30 lengths of 105-lb. 33-ft. new rail in 56 minutes, despite the fact they were held up 15 minutes waiting for the adzing gang to clear ties.

Placing Splices.—In this work two bolts were first fastened in the splice after the rail had been placed for passing trains. The remaining bolts were fastened later during spare time of men. The time for placing two bolts and splice was as follows:

Time from start to finish.	Time moving to next joint.
3 min.	30 sec.
3 min., 30 sec.	30 sec.
3 min.	1 min.
11 min. for insulated joint.	1 min.

We are indebted to A. M. Van Auken, Assistant Engineer, Monon Route, for the above data.

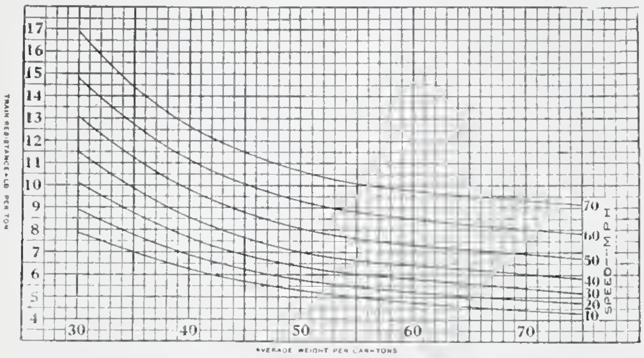
Clay in Hydraulic Fill Acts as Lubricant Upon Dredge Pipe

Most of the material which will go into the dam embankment of the Miami Conservancy District at Germantown, O., will be obtained in the main borrow-pit, occupying the width of the valley bottom just above the dam site, the excavation being done by a large dragline excavator. The quantity thus delivered up to date has not been equal to the full capacity of the dredge pump, and it was therefore considered advisable to supplement the work of the excavator by sluicing material down from the adjacent hillside through a sluiceway, the material being excavated in this case by a hydraulic monitor. It was known that the hillside contained more clay than the valley bottom, which would provide thus an additional quantity of fine material for the earth core of the dam. Also, at times when the dragline stopped work for any reason, the hillside borrow pit would be still feeding material to the dredge pump. Some interesting results were obtained from this plan, which are outlined as follows in the October Miami Conservancy Bulletin.

It was found that the large percentage of clay in the hillside material, as compared with the valley bottom borrow pit, caused it to act upon the dredge pipe as lubricant, diminishing the pipe friction to such an extent that in spite of the additional material put through by the dredge pump, the total head remained the same. There was no increase in the gage reading on either the pressure or the vacuum side. The readings are taken regularly every hour, and the records covering several days, both preceding and following the change, seem to give assurance that the conditions indicated are stable. The material from the valley bottom borrow pit amounts to about 1,500 cu. yd. per day of two 10-hour shifts. The hillside borrow pit supplies an additional 500 cu. yd. The main borrow pit material comes to the pump during about 13 hours out of the 20. The hillside material is supplied almost continuously during the double shift. The motor (alternating electric), while pumping the latter material, is run on the oil switch alone. Also the pipe was being lengthened for several days following the change. The facts, put together, would indicate (since the unchanged gage readings show no increase in work on the part of the pump) that perhaps ¾ of the additional 500 cu. yd. per day—or about 25 per cent of the total—is being put into the dam, as far as the dredge pump is concerned, for nothing. Taking all expenses into account due to the installation and operation of the hillside sluicing plant, it is estimated that the hillside material is deposited in the dam at a cost of about 10 to 12 ct. per cubic yard.

Passenger Train Resistance

An important contribution to the subject of train resistance has been made by Bulletin 110 of the Engineering Experiment Station of the University of Illinois, written by Edward C. Schmidt and Harold H. Dunn, professor and research associate, respectively, in Railway Engineering. As is well known by railway engineers, nearly all the experiments on train resistance thus far have been on freight trains on account, very naturally, of their relatively greater importance. But with the increasing speed, length and weight of passenger trains it now has been found desirable to experiment with this class of traffic.



Curves Showing the Average Relation Between Resistance and Average Car Weights for Seven Different Speeds.

The experiments were made on the Illinois Central R. R. between Champaign and Centralia. In 1908 some experiments were begun on light local traffic and were resumed in 1916 on heavy equipment in through passenger service.

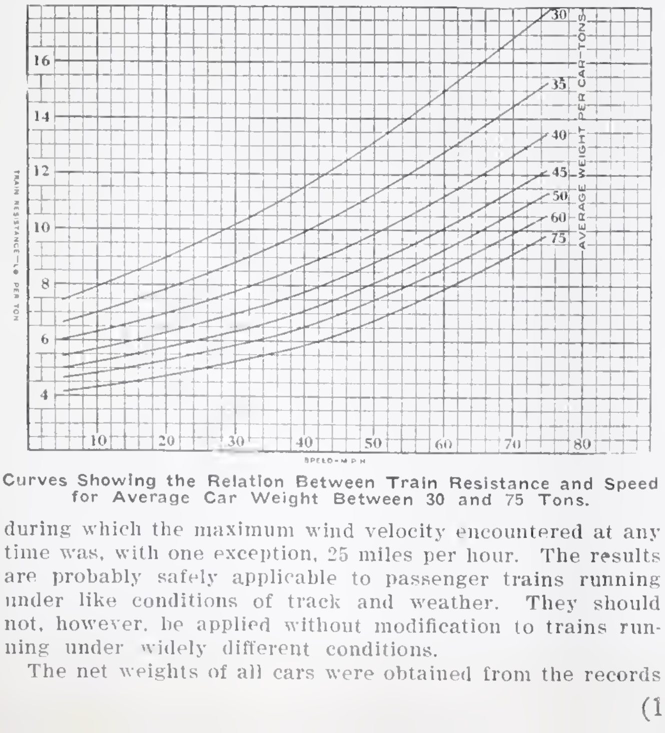
The tests were undertaken to measure the resistance of passenger trains at all speeds up to 70 miles per hour and for average car weights varying throughout the entire current range in weight. The chief characteristics of the 28 trains tested were as follows:

	Minimum.	Maximum.
Total weight (excluding locomotive and tender) tons	138	727
Number of cars in the train	4	12
Average gross weight per car, tons	33.6	71.1

Nine of these trains were in "local" service, the others in "through" service. Of the 240 cars composing these 28 trains, 178 had 6-wheel trucks, and 62 had 4-wheel trucks.

The experiments were made upon well constructed and well maintained main line track, nearly all of which is laid with either 85-lb. or 90-lb. rail. Except through station grounds where screenings or cinders are used for ballast, the track is ballasted with broken stone.

The tests were made in fair and moderate or warm weather during which the maximum wind velocity encountered at any time was, with one exception, 25 miles per hour. The results are probably safely applicable to passenger trains running under like conditions of track and weather. They should not, however, be applied without modification to trains running under widely different conditions.



Curves Showing the Relation Between Train Resistance and Speed for Average Car Weight Between 30 and 75 Tons.

The net weights of all cars were obtained from the records of the Illinois Central R. R. and the Pullman Co. To determine the car loads passengers were counted and allowed for at 140 lb. each; the weights of baggage and mail were estimated by personal inspection and count of the contents of each car; the weight of express was determined by reference to the bills, supplemented by inspection and estimate. The error entailed by these methods certainly does not exceed 15 per cent of the weight of the load, and since among all the trains the maximum load amounted to only 6.6 per cent of the gross train weight, the maximum error in gross train weight itself caused by inaccuracies in the processes described is less than 1 per cent.

The dynamometer car used in these experiments is one owned jointly by the University of Illinois and the Illinois Central R. R. The recording apparatus within the car produces continuous graphical records of the gross resistance of the train, speed, time, brake cylinder pressure, wind direction, wind velocity, and location of mile posts and other reference points.

When supplemented by an accurate profile and train data, these records permit the calculation of train resistance at any point or section on the road.

The results arrived at are shown in various tables and diagrams, the most important of the latter being herewith reproduced.

Swiss Plan of Letting Public Work Contracts

In Switzerland the average of the bids on a public work contract is the determining factor in selecting the successful bidder. The plan is described by Mr. O. P. Cherdron, president, Lynch-Cannon Engineering Co., Salt Lake City, Utah, in a recent Members News Letter of the Associated General Contractors.

Contractors of standing and proved reliability are invited to compete for public work, and before a contractor is invited, he has to have an established reputation for fairness in his dealings and competency in his profession. No bidders will be admitted except upon invitation by the public board.

After such a public board has received the bids, it will not let the work to the lowest bidder nor to the highest bidder, but it will let it to the bidder who is closest to the average bid received. For instance, on a project involving the expenditure of $200,000 there are received by the public board in Switzerland five bids, ranging as follows:

A	$ 196,000
B	218,000
C	212,500
D	197,368
E	217,950
Total sum of all bids	$1,041,818
Average bid	208,363

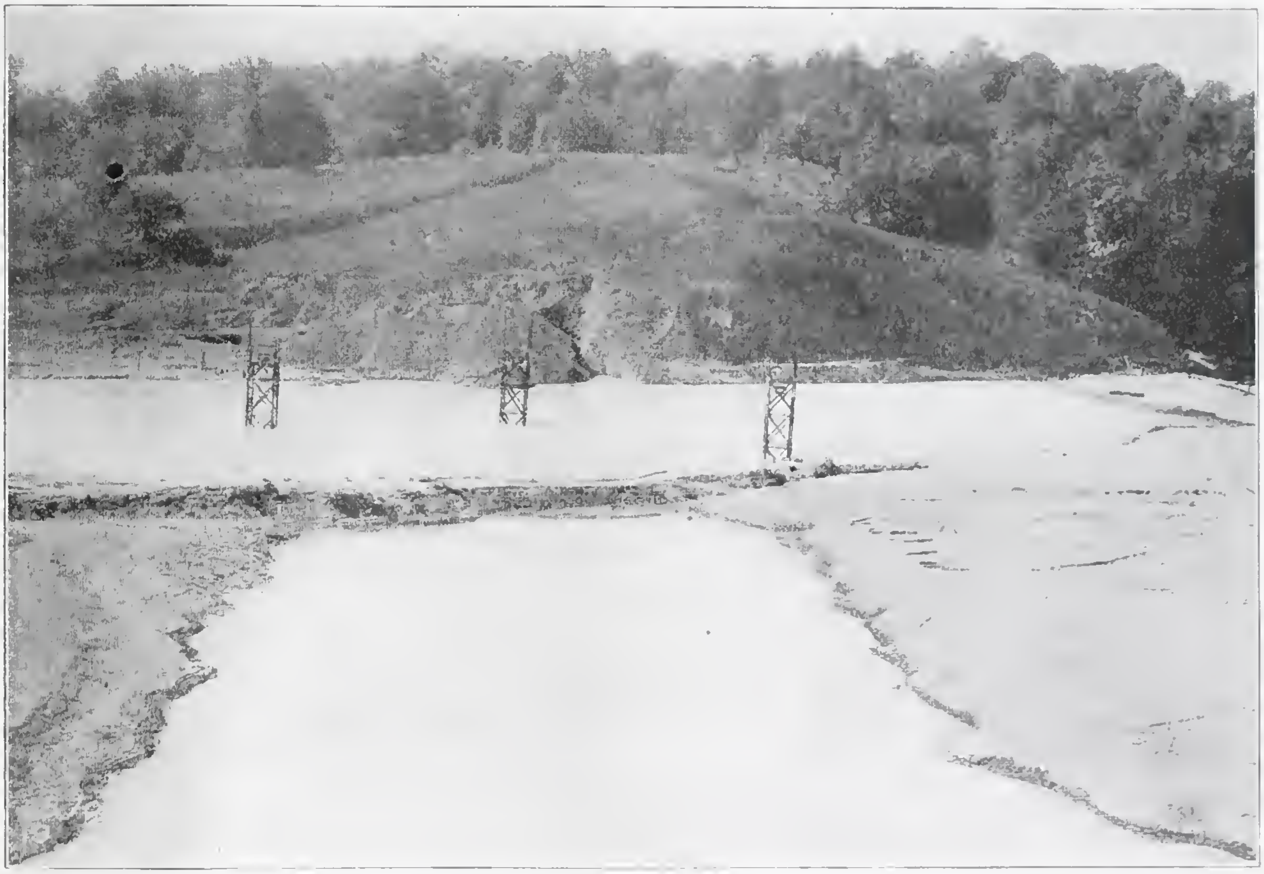
In this case bidder "C" would get the business. If a contractor should try to throw the average bid up or down by juggling, his bid would be rejected and, if he cannot prove that he made an honest mistake he would forfeit his right to bid on future public work for a certain period of time. For instance, should bidder "A" bid $120,000 instead of $196,000 and should bidder "B" bid $310,000 instead of $218,000 those two bids would be rejected by the board, and those two bidders would not be allowed to bid for a certain length of time on any work. Their bids would not be considered in the general average on this particular set of bids.

Cinder Filling Prevents Settlement of Embankment.—In constructing double track between Union City and Ansonia, O., for the Big Four R. R., considerable difficulty was encountered with sink holes. At several places the bottoms of depressions traversed by the railroad were underlaid with a stratum of peaty loam. In these locations this was so thick that the newly laid embankments squeezed it out at each side, resulting in settlements. This difficulty was finally overcome by discontinuing the use of a heavy clay filling in favor of cinders, which, being much lighter and not being subject to the flowing which took place in the clay, did not disturb the equilibrium of the subsurface materials to any great extent.

Aeroplanes and Works for Chinese Government.—The Vickers Co., London, England, has contracted to supply aeroplanes, hangars, and aeroplane works to the Chinese Government, for which they are floating a £9,000,000 ($43,798,500) loan at 8 per cent.

Measurement of Pressures in Core of Hydraulic Fill Dam

Experience has shown that the feature most needing to be watched in a hydraulic fill dam is the core, deposited by the water of the pool along the middle of the structure. Being somewhat plastic in the earlier stages of consolidation, it might, unless precautions were taken, give trouble through its tendency to thrust the dam shoulder aside and flatten out. This tendency is increased if the core is built very thick and the shoulders proportionately thin. The period requiring most watchfulness is naturally during and immediately following construction, when the core is most plastic, after deposition from the water of the pool. What needs to be known is the intensity of the earth pressure in the core interior, which measures in turn the side thrust, the tendency to flatten. Few measurements of this pressure have hitherto been made, and consequently the tests now being conducted on the dams of the Miami Conservancy District, will be watched with much interest. The methods employed by the District in making these measurements are described in the October Miami Conservancy Bulletin, to which we are indebted for the matter in our article.



Hydraulic Fill Dam in the Making. Pool at Germantown Dam, Showing Pressure Cell Towers.

The view is southward, across the damsite, nearly along the center line The cleared hillslope in the distance is the south end of the damsite. The pool next it occupies the former bed of Twin Creek, now diverted through conduits (which were too near the camera to be included in the picture). The dike between the two pools occupies the former north bank of the creek. It was thrown up to retain the waters of the nearer pool while the bed of the creek was being cleaned of objectionable materials not desired to incorporate in the dam. The wooden towers are built to carry the "pressure cells" used to measure the earth pressure in the core of the dam. This core is of fine consolidated silt and clay, pumped with the water and the rest of the earth from the "borrow pits" into the pool. The gravel and coarse materials are deposited on the sloping beaches (at the sides in the foreground). The silt and clay run into the pool with the water and settle slowly to the bottom.

The central feature of the measuring apparatus is the "pressure cell," buried in the earth of the core at the point where the determination of pressure is desired. The indicating devices are at the top of the dam, over the cell, and connected with it by small gas pipes which transmit the pressure, and by electric wires inside the pipes. The cell is a flat, hollow disc, one side of which is formed by a metallic diaphragm which receives the earth pressure. This pressure is balanced by air pressure pumped into the cell interior by a pump at the top through the pipes, the air pressure being measured by an ordinary gage. The earth pressure thus registers as directly on the air gage as the steam pressure in a boiler registers on a steam gage, except that the connecting pipe in the first case is longer. The pressure cell, buried in the dam, is virtually a diaphragm-balance, equilibrium of which is indicated by the breaking of an electrical contact carried by the center of the diaphragm, adjusted to happen just when the air pressure from the pump equals the earth pressure. An electric indicator at the top of the dam, connected with the contact point through the pipe wires, shows when the balance has been established. The air gage is read at this instant. By increasing the length of the pipes, as the dam is built up, such a cell may be made to give the pressures at any depth desired.

To make such a study complete, the pressures at all depths in the core need to be known. To secure these, cells are buried at regular intervals as the dam rises, and readings taken on all the cells. Thus a complete record will be made, giving the conditions as to pressure at all depths in the dam, and covering the entire period of construction, and also following construction. With this information at hand, as the work progresses, any corrections in the design or the construction methods can be made which may be advisable.

At the Germantown dam, the cells are suspended from wooden towers which are built up as the dam rises in height.

Three of these towers are shown in the illustration, their relation to the center line of the dam being indicated by the center line trench in the hillslope beyond them. Three sets of cells are being used here to investigate the relation of pressures at the center and near the edges of the core. Similar cells will be placed in the core at all the other dams.

Canvas Tube Facilitates Water Distribution in Sluicing Operations.—A more flexible distribution of sluicing water in hydraulic fill operations in connection with the Miami River flood protection works is obtained by attaching a canvas nozzle tube to be fixed pipe line.

Safety Factors in the Use of Explosives in Quarrying

Due to a better knowledge of the characteristics of explosives, and a more complete understanding of the proper methods for their handling, the number of accidents arising from their use is constantly decreasing. Accidents do not "just happen"; behind every accident there must be a chain of circumstances which lead, step by step, up to the final result, and the more complete our information is in regard to the influences of all the factors entering into any given operation or procedure, the simpler it will be finally to bring that operation or procedure to a basis in which the chance of accidents will be reduced to a minimum. An interesting discussion of these factors was given by Dr. Walter O. Snelling, Director of Research, Trojan Powder Co., in a paper presented last month at the 8th annual Safety Congress of the National Safety Council. An abstract of the paper follows.

Precautions in Unloading Explosives from Cars.—The first point at which the quarry superintendent is likely to be concerned with the handling of high explosives, is in unloading the car which brings the material from the manufacturer's plant or magazine. The manner in which the cases are packed in the car is prescribed by the rules of the Interstate Commerce Commission, the method having been carefully worked out with the thought in mind of reducing transportation risks to a minimum, and insuring the consignment of explosives reaching its destination in good condition.

It is quite uncommon to have a car of explosives arrive in damaged condition, but where the contents are found to be damaged, and cases are broken or otherwise in improper condition the matter should be reported to the transportation company, and the condition of the damaged cases should be carefully determined. If there is evidence that the roof of a car has leaked it is always advisable to examine the condition of the cases of explosives under the leak quite carefully. Nitrostarch explosives when very wet become insensitive and difficult to explode, while nitroglycerin explosives under the same conditions tend to "leak" nitroglycerin, and this free nitroglycerin is of course far more dangerous than is the nitroglycerin in absorbed condition in the original explosive. Cases of explosives which show exudation of nitroglycerin should be handled with the most extreme care, and every precaution should be used to avoid any friction, or any jam or blow that might be sufficient to cause an initial explosion which would undoubtedly communicate at once to the entire lot of explosives.

In unloading a car of explosives, just as in handling the cases of explosives in all subsequent operations, care should be taken to avoid unnecessary rough handling. It is true that cases are on record where boxes of dynamite have fallen in quarries for a vertical distance of 100 ft. or more without explosion, and it is also true that railroad accidents have occurred in which cars loaded with explosives have been literally torn to pieces without explosion resulting. It is just such facts as these that make it so difficult for the average user of explosives to hold a proper mental conception of the degree of care which should be used in handling explosives and to draw a clear distinction between that over cautiousness which leads to a general fear of explosives on the one hand, and such careless handling on the other hand as amounts to true foolhardiness.

A case of high explosives need not be handled with quite the same care that would be given to a crate of eggs, nor can it be handled with quite the same roughness that would be used with a block of stone. Between the two extremes lies that safe ground which leads to the handling of a case of explosives with that degree of care which its nature warrants, and yet with the absolute assurance that when handled in this careful way the case of explosives is practically as safe to handle as any other box of like weight would be.

It is needless to say that the throwing of cases of explosives from a car to a man on the ground is to be condemned, as is also the too rapid passing of cases of explosives through a chute. I have often seen explosives loaded through a chute of considerable length, and once during the unloading of an explosive from a boat I saw a case of explosives broken open by striking another case of explosives which had become stuck at the bottom of the chute. I do not doubt that this sort of handling could be repeated many times without explosion, but nevertheless I feel confident that the operation involves some risk and is therefore to be condemned. The handling of the cases, a few at a time by means of a small truck is decidedly preferable to the use of a chute unless it is quite a short one, and the passing of a case of explosives from one man to another is a great deal better than the throwing of the case, with the possibility of the man failing to make a good catch and dropping the case.

Magazines for Storage of Explosives.—A good deal might be said as to magazines for the storage of explosives. It is most desirable that a magazine should be water-tight and well ventilated, and in addition should be located sufficiently far from surrounding buildings to offer proper safety. As to the actual type of construction for a magazine opinions differ widely. The Bureau of Mines advocates magazines made of cement-mortar, and Technical Paper 18 gives a rather full description with bill of materials for a magazine with a capacity of 20,000 to 30,000 lb. of explosive. At the time the Technical Paper 18 was published the cost of a magazine of this kind was $400, but the price would of course be materially higher at the present time. The walls of the Bureau of Mines magazine are 6 in. thick, and the roof and door, both of which are also of cement-mortar, are 3 in. thick.

The principal advantages of cement mortar of the composition suggested by the Bureau of Mines is that the material is substantially bullet proof, and yet crumbles so readily under a blow such as would be produced by an explosion as to greatly reduce the danger from large flying pieces of material.

Where it is desirable to carry a large stock of high explosives at a quarry, it is preferable to provide a main magazine located at a safe distance from the quarry, and an auxiliary magazine close to the quarry for the day's supply of explosives. The magazine for high explosives should always be located a proper distance from the detonator magazine or storehouse, and it is very important always to bear in mind that detonators and high explosives should never be stored together. In spite of the fact that the storing of detonators with high explosives has been most strongly condemned by government and state bureaus, and by practically all investigators who have studied the matter, one occasionally sees rather clear violations of this simple rule of safety.

The selection of a magazine site, particularly for the main magazine, is a matter to which some thought can profitably be given. It is well recognized that an outcropping rock ledge forms a less desirable location for a magazine than alluvial earth or sand, since in the event of an explosion the earth waves are transmitted to a considerably greater extent through rock, and destructive effects are thus more extended than when a magazine is on a compressible and less rigid foundation.

Thawing Explosives.—Where nitroglycerin explosives are being used during cold weather it is necessary to provide a thaw house in order to insure the explosives reaching the work in proper condition. It is interesting to note that frozen explosives appear less sensitive to a detonator, and more sensitive to ordinary shocks or blows than the explosive in its normal condition. This subject has been under investigation for a number of years, and a large amount of information as to the cause of this peculiar phenomenon has been accumulated. At the present time the belief seems to be that although frozen nitroglycerin is relatively much less sensitive than liquid nitroglycerin, yet frozen explosives, in part because of their rigid condition and in part because of the presence within them of crystals of nitroglycerin, are in unfavorable condition to resist friction and forces which tend to distort the form of the cartridges.

The thawing of frozen explosives should always be carried out at a relatively low temperature, and any effort to quicken the thawing action is to be condemned. When only small amounts of explosives have to be thawed, a double jacketed vessel may be used, in which the heating agent is water at a temperature of about 50° C. (122° F.) The temperature should never exceed 55° C. (131° F.)

While explosives are being thawed their sensitiveness seems to be increased somewhat, and accordingly both during the thawing operation and while the explosive is still warm after thawing, exceptional care in handling should be exercised.

Where a considerable amount of explosive has to be thawed, it is best to make provision for thawing at one time the entire amount of explosive used in a day, and for this purpose a special thawing house is necessary. The thawing house should be located at a safe distance from all quarry buildings, and should be provided with some means of indirect heating. Technical Paper 18 of the Bureau of Mines describes a type of thaw house which is recommended by the Bureau; and in which exhaust steam or hot water is utilized as a means of supplying heat, the heating coils being placed in a small shed adjacent to the thaw house proper.

"Make-shift" methods of thawing have led to frequent accidents, and it should aways be borne in mind that the thawing of frozen explosives is an operation which should be given careful thought. Where the electric current is available it has been the custom in some quarries to place resistance coils or resistance bars in a magazine for the purpose of maintaining a temperature above that at which the explosives freeze, but accidents have been directly traced to this arrangement, and indirect heating, with the heating element placed in an auxiliary fireproof box connected with the thaw house by a flue or by some other like means, is much to be preferred.

In thawing explosives the use of a high temperature for a short time is much less desirable than a considerably lower temperature for a longer period. Although temperatures as high as 50° C. (122° F.) are sometimes used a temperature of 40° C. (104° F.) is much to be preferred. The long-continued exposure of explosives in a thaw house should be avoided, and the Bureau of Mines has called attention to the fact that some explosives, such as gelatin dynamites, have been known to decompose and explode after only a few days when continuously heated.

Primary and Secondary Blasting.—With proper explosives from 3½ to 4½ tons of rock can usually be obtained per pound of explosive used, but this also is a factor which is dependent upon many conditions in the quarry, so that a direct comparison between blasting in one district and in another district is often impossible, and sometimes leads to conclusions which are unfair to really good practice in a district in which unfavorable conditions such as clay parting seams exist. I have known of districts in which the "lay" of the rock and its toughness have caused 2½ tons per pound of powder to represent really excellent blasting, and I have also seen districts in which 4 tons of rock per pound of powder was being produced by blasting methods which by improvement could easily have been raised to at least 4½ tons per pound of powder and possibly some little higher.

It should be remembered that the cost of the powder in the blast is far from being the sole factor to be considered in blasting costs. Many a quarry superintendent has found to his cost that a primary blast in which too little powder was used may lead to an increase in the cost of shovel work and of secondary blasting entirely out of line with the small difference between the cost of the powder originally used, and that which would have been required for a well-balanced shot.

It is the cost of the rock at the crusher which the quarry superintendent should regard as his standard of comparison, rather than the cost per ton of the rock immediately after a shot. Frequently it will be found that adding 1 or 2 ct. per ton to the cost of the primary blasting will result in a reduction of 3 to 4 cts. in the cost of secondary blasting and steam shovel operation and the wisest economy is that which looks beyond the first cost, and gives careful consideration to the ultimate cost.

Secondary blasting is at best to be regarded as a necessary evil. Modern practice tends to reduce secondary blasting to a minimum by the following methods:

a. Improvements in primary blasting, for the purpose of reducing to a minimum the amount of rock which must be block-holed or bulldozed.

b. Increase in the size of shovels and cars, and increase in the opening of the crusher to take rock in larger sized pieces.

These two methods of procedure should in fact go hand in hand, and as manufacturers are today building crushing machinery of greater strength and with increased size of inlet, and increased skill on the part of the superintendents and foremen is leading to constant improvements in blasting methods, we can confidently look forward to a steady improvement in regard to secondary blasting operations.

Cordeau and Electric Detonator Methods of Firing Blasts.—Two methods of simultaneously firing a number of shots in quarrying are available, one method being by the use of electric detonators, and the other by the use of detonating fuse or cordeau.

Cordeau, frequently known as "Cordeau detonant, or Cordeau Bickford," is lead tubing filled with T. N. T. Experiments have shown that such cordeau explodes at the rate of approximately 5,300 meters per second, and accordingly where a number of holes are connected together by means of lines of cordeau the holes become in effect one single hole.

Electric detonators are copper capsules which contain a detonating charge of fulminate of mercury or equivalent material, and a small loop or "bridge" of very fine wire, which can be heated red hot by the passage of a very small electric current. As the rate at which an electric current travels is stated to be 300,000 kilometers per second (186,000 miles per second), it is evident that where a number of electric detonators are connected to a single source of electric current, their detonation is absolutely simultaneous for all practical purposes.

Both cordeau and electric detonators have their advantages and disadvantages for the simultaneous firing of large blasts. Where a number of widely separate charges are to be simultaneously fired electric detonators have some advantage over the use of cordeau, while on the other hand cordeau has some advantage in wet holes, and particularly in holes where the explosive charge is interrupted by lengths of stemming for the purpose of "raising" the average height of the charge.

One of the advantages possessed by cordeau is that as the line of cordeau extends the entire length of each hole, the entire column of explosive is brought into detonation at a speed which is determined by the rate of detonation of the cordeau itself. If, for example, a hole of 100 ft. deep were to be filled with an explosive having a rate of detonation of 3,000 meters per second, and the explosion of its charge to be brought about by an electric detonator placed in the bottom of the hole, the detonating wave would pass through the column of explosive at this rate of 3,000 meters per second. If instead of this arrangement a line of cordeau extended from the top to the bottom of the hole it is evident that this would communicate detonation to all parts of the explosive in contact with the cordeau at the rate of detonation of the cordeau itself, instead of at the normal rate of detonation of the explosive. The explosive would still probably detonate at its normal rate, but the cordeau would increase the rate at which the column of explosive would detonate through its length. Opinions differ as to the advantages which are gained from this simultaneous detonation of the entire length of a column of relatively slow explosive. For certain special purposes there can be little doubt that it helps bring about a desired "timing" of the explosion of several different types of explosive used in a single blast, and possessing different normal rates of detonation. The use of cordeau as a convenient and safe means of simultaneously firing a number of holes is increasing, and many quarries have replaced the use of electric detonators by this method of firing holes.

When electric detonators are used in blasting in well-drill holes, the best practice is thought to be the use of at least two detonators in each hole. The detonators should be so spaced that the uppermost detonator is about equally far from the top of the column of the powder and from the center of the charge, and the lower-most detonator is similarly equally far from the bottom of the charge and from the middle of the charge. By this arrangement the detonator occupies the center of the column of explosive of which it is to bring about the detonation. In a well-drill hole having 60 ft. of powder the lower detonator would be 15 ft. from the bottom of the hole, and the upper detonator would be 15 ft. from the top of the column of explosive, the two detonators being 30 ft. apart. Whenever electric detonators are used, care should be taken that several feet of powder are above the detonator, before tamping the powder, since the fulminate contained in detonating caps is much more sensitive than any high explosive used for blasting purposes, and the striking of a detonator by the tamping bar, and particularly the grinding of a detonator between the tamping bar and the side of a hole, would be practically certain to lead to an accident.

In lowering detonators into the hole the best practice is to attach the detonator properly to a cartridge of explosive so that the cartridge will hang perfectly plumb when suspended from the wire. The cartridge is then lowered by means of the wires to its proper position in the hole. If sufficient care is not taken to have the cartridge of explosive hang plumb from the wire it is very apt to strike against the side of the hole while being lowered, and to cause a "jam."

On account of the detonator being in the cartridge, a cartridge so caught should of course be dislodged with considerable caution, and it is better to take a little more care in arranging this priming cartridge, so as to avoid the difficulty and danger of attempting to dislodge it when caught.

When cordeau is used in the hole, it is also best to use a cartridge as a "weight" to carry the cordeau to the bottom of the hole. The advantage of having a cartridge on the end of the line of cordeau, in addition to keeping the cordeau straight, is that it enables the blasting foreman to tell by the "feel" as soon as the line of cordeau has reached the bottom of the hole.

No advantage is gained by having more than one line of cordeau in a hole, and accordingly this is never done. If there is reason to believe that a line of cordeau has been broken off in the hole it is sometimes good practice to lower another line of cordeau into the hole to the depth at which the break of the first line is known to have occurred.

In using cordeau, it is well to remember that in spite of the remarkable rate at which the explosive wave passes through the material, it does not have the ability to jump a gap. Even so small a space as two or three millimeters (one-eight of an inch) acts as an efficient barrier against the the transmission of the detonating wave, and for successful results it is imperative that there should be no break whatever in the continuity of the line of cordeau.

In primary blasting the use of well-drill holes has now largely supplanted earlier methods of bench work, and although I will discuss safety precautions mainly from the standpoint of well-drill methods, the same principles will generally hold good wherever open cut blasting work is being done.

Precautions in Loading Blast Holes.—In the loading of holes particular watchfulness should be given to insure the complete absence of sparks or hot cinders from the steam shovel, from locomotives, or from the steam well-driller. Those who have watched a steam shovel at work at night will probably have a better appreciation of the menace that sparks represent, than those who have only seen the work going on by daylight, and it should be remembered that it is not only those sparks which are visibly red which are capable of igniting explosives, but that hot cinders which appear quite black may be at a sufficiently high temperature to bring about an ignition. I am inclined to believe that rather more accidents during loading are caused by hot cinders than are usually attributed to that cause, and the only safe practice is to keep all sources of sparks away from the vicinity of the holes during the time that loading is going on. Some quarries have small tents which are placed over the holes while they are being loaded, and while this is better than no protection whatever, yet it is not as satisfactory as the complete removal of sources of sparks during the time of loading.

Of course lighted pipes, cigarettes or cigars should be rigidly excluded from the vicinity of loading operations. It is even best that men engaged in loading should have no matches in their possession, since a hole in a man's pocket or some other accidental condition hard to anticipate may lead to a match dropping down in the hole, or falling on the rock near the hole where it may be stepped on by the men loading the hole. Even gasoline engines are to be considered as a potential source of sparks. It is true that a gasoline engine only occasionally throws out sparks, but the carbon which accumulates on the piston head and at the end of the cylinder is ejected from time to time in glowing condition, and this, together with an occasional backfire makes a gasoline engine a possible source of accident if too near a hole during loading.

In loading the hole with explosive, it has been proposed from time to time to use holders or clamps of various sorts, in order to avoid dropping the explosive to the depth of the hole. These are not commonly used, however, and experience seems to show that the hazard in dropping a cartridge of explosive through a hole 100 or even 150 ft. deep, is very small indeed. The first cartridge would naturally seem to be the one most likely to explode if detonation from the shock of dropping were really a considerable factor, since the later cartridge drops on the cushion formed by the cartridge already in the hole.

The experienced blaster is able to learn a good deal about the condition of the hole from the sound made by the first cartridge as it drops down and the sound of the cartridge striking the bottom of the hole, or striking the surface of the water if the hole is wet, is used to determine the fact that the cartridge has gone completely to the bottom. It is excellent practice to "follow-up" the hole by measurements after each case of powder has been loaded, a case of powder ordinarily giving a "rise" of about 4 ft. There is always the chance of cartridges "hanging" on the side of the holes, and thus leaving an air gap between the powder beneath which has been loaded properly and the point at which the first cartdridge thus becomes crossed in the hole. If the "rise" in the hole is carefully followed by frequent measurements such a "block" in the hole will be promptly noticed, and the condition can be readily corrected, but if a considerable amount of powder is loaded over the crossed cartridge before it is discovered that a "choke" exists, the matter is naturally more difficult to correct. An experienced loader can usually tell from the sound made by each cartridge as it drops that it has landed properly on the powder already in the hole, but occasionally a cartridge will hang on the sides of the hole even with good loading practice. A single cartridge can be dislodged safely by the careful use of a tamping stick, but if the "hanging" of the cartridge has not been noticed, and more powder has been loaded on top of this cartridge, so as to leave a column of 2 or 3 ft. of powder above the choke, the dislodging of the material becomes more difficult. Efforts to dislodge such a choke by the vigorous use of the tamping bar are decidedly dangerous, and this procedure should never be followed. The best practice is of course to prevent any column of powder from building up on a "choke," by using the measuring line sufficiently frequently to keep in close touch with the level of the powder in the hole, and by paying proper attention to the sound made by the dropping cartridges as they land on the powder beneath. If a "choke" should occur, however, and more than a foot or so of powder should be built up over the crossed cartridge, the safest procedure is usually believed to be the cautious driving of sharpened stick about 2 in. in diameter through the "choke," followed by the flushing out of the powder above the "choke" by means of water. Unless a quite excessive amount of water is used, this procedure will not cause the loss of the hole, as the powder will detonate in spite of a rather considerable amount of water which may be present after this treatment.

The size of the cartridges used in loading the hole is not a matter of indifference. For the standard 5⅝-in. well-drill hole the 4½-in. by 10-in. cartridges are commonly used, unless the hole is quite rough and ragged, in which case 4-in. by 8-in. or 4-in. by 10-in. cartridges are used. Using cartridges which are too small is a disadvantage, because the proper density in the hole is then more difficult to attain, while using too large cartridges is a disadvantage, because the chance of such cartridges catching on the side of the hole is materially increased. As a matter of fact the chance of a cartridge choking a hole is increased by the use of cartridges which are either too small or too large, and for well-drill holes the cartridge should preferably be 1 in. smaller than the diameter of the hole.

In measuring the hole a special tape gives the best results, although in many quarries the tamping stick rope is used instead. Whatever may be the method adopted to keep track of the height of the powder in the hole, the point which should be brought out is the desirability of the measurements being made so frequently as to enable the loader always to know the height of the powder in his hole.

Tamping Explosives.—The extent to which powder should be tamped during loading really depends upon the type of explosive which is being loaded, and therefore should more properly be considered in connection with a discussion of the selection of power for various types of blasting. Tamping of the explosive during loading is quite desirable in the case of the more plastic nitroglycerin explosives, but increasing use is being made in cement rock quarrying of explosives, which require little tamping, and indeed in many quarries the explosive is not tamped during the loading, the tamping bar being only used at the end of the loading operation in compacting the stemming in the hole.

If explosives are to be tamped, however, it is most important that too much force should not be used. A rather considerable number of accidents have been due to improper use of the tamping bar, and to the use of unsuitable materials as tamping bars. It should be evident from what has already been said that the presence of any iron surfaces on the tamping bar is a potential source of danger, and that the use of too heavy a tamping bar also involves a rather heavy risk. I have sometimes been told that a heavy tamping bar has advantages when it is properly used, and there may be some truth in this, but the fact remains that when improperly used such a bar becomes a source of danger, and the chance of the bar being improperly used is always present. I have been told of one case in which a type of tamping bar which has been used for some years with perfect safety by a powder foreman was used in his absence by a less experienced man, and in the course of the loading operation a choke developed and an effort was made to drive it out with the tamping bar, and an accident resulted. A lighter tamping bar would have been safer in this case, just because of the possibility of the misuse of a heavier bar by an inexperienced or careless man.

I have seen some rather surprising tamping bars at various times, ranging all the way from solid iron bars to iron tipped wooden rods. Once, in investigating a "mysterious" accident which had occurred on a piece of railroad work on which a nitroglycerin explosive of low nitroglycerin content was being used, I found that although suitable wooden tamping bars were supplied to the powder men by the contractor, a powder foreman had shoes made of lengths of iron pipe fastened to the end of each of the bars "to keep them from fraying out so quick," and naturally the inevitable happened, and several men lost their lives in the resulting explosion.

Even wooden tamping bars can be unsafe if too heavy or if carelessly handled. It is not infrequent for sharp pieces of rock to become imbedded in the bottom or sides of a wooden tamping bar, and no one needs to be told that such a tamping bar will strike a spark under favorable conditions by rubbing against the side of a rough hole. The tamping bar should not be too large, in order to avoid excessive friction against the side of a hole, this precaution being particularly important in connection with piston drill holes.

A suitable layer of powder should always overlie each priming cartridge containing a detonator. Detonators are always to be treated with great respect, and having 2 or 3 ft. of powder above the detonator before alowing any tamping to be done is an excellent rule.

The energy that might otherwise be spent in tamping the powder can be utilized to advantage at the top of the hole in thoroughly tamping down the stemming which is applied over the powder. The first 2 or 3 ft. of stemming should not be tamped, but after this the stemming can be tamped down quite hard, and indeed, if care is taken not to damage the line of cordeau or the electric feed wires, it may almost be said that the harder the tamping of the stemming material, the more efficient the shot will be. Experiments have demonstrated this point rather thoroughly, and a shot which is well confined does perceptibly more work per pound of powder used than can be obtained from a shot in which poorer confinement has been provided.

It is usually unnecessary for workmen to stand on the rock lying in front of the line of holes after the loading begins, and this is a safety precaution which may accordingly be given consideration. Should a premature explosion occur from any cause during the loading operation, the chance of men being injured is naturally less if the workmen are on the far side of the line of holes, isteead of between them and the quarry face.

Precautions for Making Final Connections to Blast.—It is of course evident that the final connecting up of the electric detonator wires, or the cordeau connections, should not be made until shortly before the blast is ready to be fired. When electric detonators are used, the method of wiring or connecting up a shot is a matter to which thought should be given. Where only a few shots are to be fired the detonators are often arranged in series, and fired by a blasting machine of the usual type, but in quarries where a good deal of blasting is being done, and where quite a number of holes are to be fired at one time, the parallel method of wiring is often preferred, the electric current being furnished from the power circuit. The connections should always be in parallel when current from a live wire is used in firing the blast.

As electric detonators are sensitive to relatively small circuits, and may be fired by "stray" currents the existence of which may not have previously been known, the wiring should always be in the hands of competent and trustworthy men, and the holes should not be connected up until the shot is practically ready to be fired. Several cases are known where electric detonators have exploded apparently without cause, and investigation has shown that the wires were abraded at certain points, so that direct contact was established with moist earth or with some conducting metal. In coal mining several accidents have occurred through stray currents from a passing electric locomotive finding passage through an abraded wire to a charge which was not yet ready to be fired, and at least one accident in a cement quarry has been found to be due to a quite similar cause. These accidents only emphasize the point already brought out, that the lead wires connecting up the separate holes should only be attached when the tamping of the holes has been completed, and when the blast is ready to be fired. In addition, the lead wires should always be kept in good condition, and should be taped if any abraded spots are found.

One of the points which is to be avoided in the connecting up of a blast is too great haste in making the electrical connections. Wires loosely twisted together do not form a good electrical connection, and more than one quarry superintendent has no doubt criticized his powder foreman and his blasting men for a poor blast that has in fact been due to the failure of some of the holes to be fired by the electric current, the detonation of these holes coming through the shock from adjacent holes, and too late to enable the explosive to do its proper share of work in the blast.

The lead wires should not be brought near the exploder wires while loading is going on, and all the connections of the blast should be completed before connecting to the lead wires. The custom of having shots connected up to the lead wires and firing battery before work around the holes has been completed is strongly condemned, and there is always the possibility that some one will unintentionally fire the blast under these conditions, in the effort to "test out" the battery or the connections without realizing that electric detonators are in the circuit. Probably the safest method that I have seen for preventing accidents from the unintentional applying of current before the blast is ready is the placing in the circuit of a special block, which leaves the circuit open unless a special form of key is placed in it. The key is retained by the man responsible for the blast until the time that the current is to be applied, and is then inserted. Where firing is done from a power circuit a modification of the same principle may be applied, or the switch connecting the lead wires may be locked in position some suitable way. The one point which I consider quite important is that one man should be responsible for the circuit, and that this man alone should have the key controlling the switch or the safety block.

In firing with cordeau the electrical circuit should be made before the exploder is placed in the special union which connects the detonator with the main strand of cordeau. The manufacturers of cordeau provide special attachments which may be used either with electric detonators or with detonating caps, and in addition special tools are provided for slitting cordeau in the making of connections and joints.

Block Holing and Mud Capping.—The rules for safety and efficiency in the handling of explosives in connection with secondary blasting operations are of course not dissimilar from those rules which should be followed in primary blasting operations. In block-holing 1 lb. of explosive will do fully the execution that 10 lb. of the same explosive will even in a well placed "dobie," or mud cap shot, while a poorly placed mud cap shot is notoriously wasteful of explosive. It is frequently economical to use the larger quantity of explosive required by the mud cap shot, because of the cost of the drilling of the holes in the block-holing method. A few years ago the situation was much more difficult than it is at present, but recent improvements in light air hammers have materially cut down the cost of secondary drilling, so that the alert quarry superintendent will bear constantly in mind the advantages for and against the block-holing method. Where mud capping is done, it is well to remember that earth and clay are much cheaper than explosive, and that a somewhat larger pile of dirt will be equivalent to a noticeable amount of explosive in the charge that is necessary to break the rock.

Proper protection for workmen in the quarry from fragments thrown by the blast should of course be provided. The usual cylindrical safety shanties of boiler plate provide rather satisfactory protection if located at a suitable distance, and if the doors or openings are turned away from the direction of the blast.

Factors in Design of Sluices and Pipe Lines for Hydraulicing*

By F. A. GOODALE.

Factors Which Determine Size and Grade of Sluice.—Many conditions influence the size and grade of the sluices and tunnels, such as character of the gold, whether fine or coarse; and the kind of gravel. Top or fine gravel will run much faster than medium, or cemented, with the same grade of sluice. If the gold is uniformly fine it will travel all the way through a flume and be lost in the tailing, if run on the same grade as a sluice used for a gravel bank whose gold content is coarse.

I use the following empirical formula for estimating what a flume will carry and the grade to use:

For very free or top gravel.

1. The number of cubic yards of gravel moved per hour through a flume = 60/24 times the number of miner's inches of water divided by 40, times the grade of the sluice in per cent.

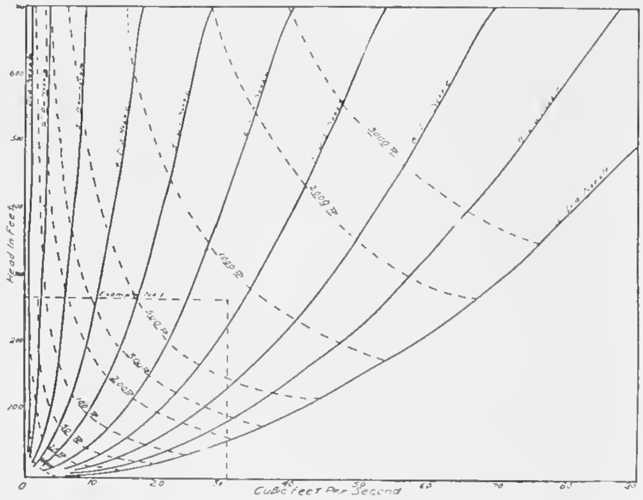


Fig. 1—Curve Showing Amount of Water and Horsepower Delivered Under Pressure Through Various Sized Nozzles.

2. For medium gravel: The number of cubic yards per hour = 40/24 times the number of miner's inches of water divided by 40, times the grade of the sluice in per cent.

3. For cement gravel: The number of cubic yards per hour = 20/24 times the number of miner's inches of water divided by 40, times the grade of the sluice in per cent.

Example: Two monitors using 2,000 in. of water are working on top dirt which is very free gravel, and the sluice is on a 3 per cent grade. How much gravel will be moved per hour? How much for cement gravel?

Amount of gravel moved per hour =

$$\frac{60}{24} \times \frac{2000}{40} \times 3 = 375 \text{ cu. yd.}$$

Amount per hour for medium gravel:

$$\frac{40}{24} \times \frac{2000}{40} \times 3 = 250 \text{ cu. yd.}$$

Amount per hour for cement =

$$\frac{20}{24} \times \frac{2000}{40} \times 3 = 125 \text{ cu. yd.}$$

Knowing the grade, the amount of water to be used, and the character of the gravel, the size of the sluice box can be calculated to handle the required amount of material. For minimum first cost and wetted perimeter, the sluice width should be about twice the depth of the stream. About 35 per cent should be added to the depth, because a sluice should not run more than ¾ full, and 35 per cent to the width to accommodate the water and material. Fine gravel requires a wider flume with more grade than coarse gravel and gold, and should be shallow. Each mine is a problem in itself and must be carefully studied, for there are many influences brought to bear by differences in character of gravel and topography. I have noticed that pipemen coming from other mines in the same locality have a difficult time to run the maximum amount of gravel with the minimum amount of trouble, until they "learn the layout." Some of them are good on "grass roots dirt" but are "up against it" when it comes to handling cemented gravel.

The top gravel will nearly always cut easily with most any kind of a stream, while the medium gravel, or that usually above the cement, requires water under the high pressure line, which at the You Bet Mine is 300 ft. The bottom or cement gravel is mostly bank blasted, to shatter the gravel and free the gold as much as possible.

Graphical Representation of Formulæ Used in Designing Hydraulic Pipe Lines.—I have plotted some curves for rapidly estimating the amount of water delivered through different sized nozzles under various heads, and the approximate horsepower developed. Also a curve for figuring the proper size pipe to overcome friction, having the grade and quantity of water available for hydraulicking.

The following examples will illustrate their use:

Between the pressure box and nozzles of a pipe line 22 in. in diameter, the distance is 1,450 ft. and the difference in elevation 300 ft. The pipe is to carry 1,200 California miner's inches (30 cu. ft. per sec.) which is to be discharged through one giant. What size nozzle is necessary and what is the approximate horsepower developed?

From Fig. 2, the head necessary to overcome friction per 1,000 ft. of pipe is 22.0 ft., and for 1,450 ft. of pipe is 1.45 × 22.0 = 31.90 ft. Then the total head, 300 ft. — 31.90 ft. = 268 10 ft., which is the available head.

Then from Fig. 1, 30 cu. ft. per sec. under 268 ft. head gives a 6¾-in. nozzle, but a 7-in. diameter nozzle would be selected. By interpolation approximately 870 HP. would be developed.

Theoretical solution:

Cox's formula for friction head—

$$(H) = \frac{l}{d} \times \frac{4v^2 + 5v - 2}{1200}$$

where l = length of pipe in feet.
v = velocity of water in feet per second
d = diameter of pipe in inches = 22
q = cubic feet per second = 30
a = area in square feet = 2.64

$$v = \frac{q}{a} = \frac{30}{2.64} = 11.38 \text{ ft. per sec.}$$

$$\text{Then } H = \frac{1450}{22} \times \frac{4(11.38)^2 + (5 \times 11.38) - 2}{1200} = 31.7 \text{ ft.}$$

Total head 300 ft. — friction head 31.7 = 268.3 ft. = head available. $v = 93\sqrt{2gh}$ = spouting velocity of nozzle = $.93 \times \sqrt{64.4 \times 268.3} = 122$ ft. per second. $q = a \times v$ and

$$a = \frac{q}{v} = \frac{30}{122} = .246 \text{ sq. ft.} \quad \frac{\pi d^2}{4} = A = .246 \quad d = .56 \text{ or}$$

6.73 in. Therefore a 7-in. nozzle would be selected.

$$\text{H. P.} = \frac{62.5 \times 30}{550} \times 268.3 \times .93 = 850.$$

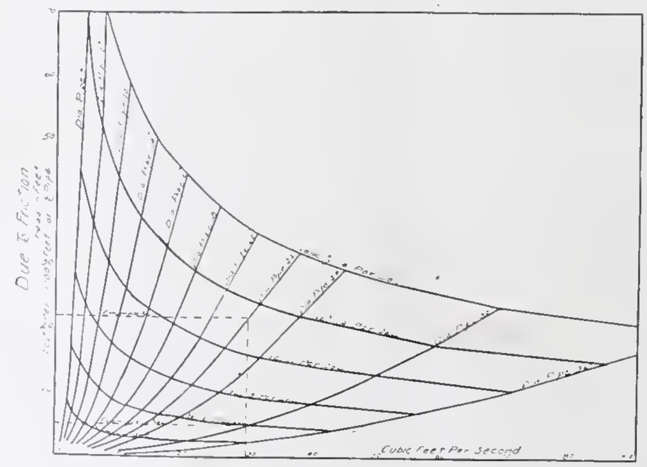


Fig. 2—Curve Showing Various Size Pipe Head Lost Due to Friction. Velocity in Feet Per Second and Discharge in Cubic Feet Per Second.

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*From an article in The Colorado School of Mines Magazine on hydraulic mining in California.

This is less than approximated by diagram.

The length of an inverted siphon is 1,200 ft. What should be the difference in elevation between the intake and outlet for a pipe 30 in. in diameter to deliver 1,200 in. of water?

By diagram, friction head = 5 ft. per 1,000 ft. of pipe; and for 1,200 ft. of pipe it is 1.2 × 5 = 6 ft., which is the head necessary to deliver the required water. Theoretically, by Cox's formula:

$$h = \frac{4v^2 + 5v - 2}{1200} + \frac{1}{d}$$

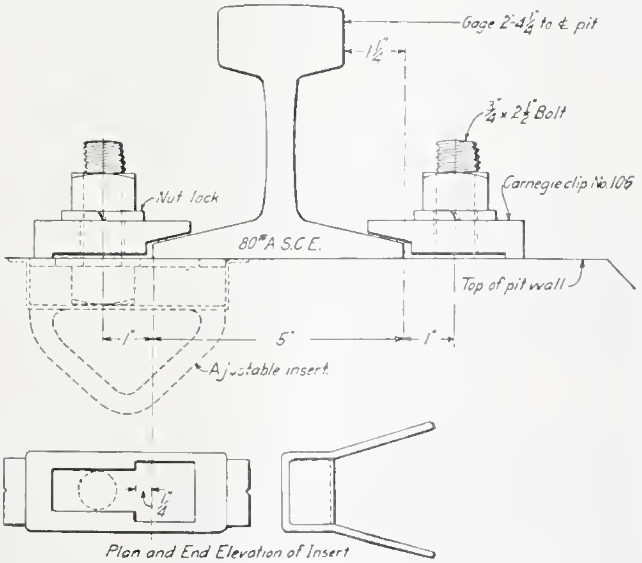
$$v = \frac{q}{a} \quad \text{Area of 30-in. pipe} = 4.909 \text{ sq. ft.}$$

$$v = \frac{30}{4.909} = 6.1$$

$$h = \frac{4 \times (6.1)^2 \times (546.1) - 2}{1200} \times \frac{1200}{30} = 5.9 \text{ ft.}$$

Bolt Inserts for Rail Fastenings in Roundhouse

Bolt inserts embedded in the concrete were used for fastening the rails to the walls of track pits in the new roundhouse of the Toledo & Ohio Central R. R. at Columbus, O. Instead of embedding timber blocks in the walls to which the rails could be spiked in the ordinary manner or embedding bolts head down, direct in the concrete, metal inserts were used as shown in the drawing. These inserts are essentially metal boxes containing a receptacle for a bolt head with a suitable slot for inserting the bolt and with wings extending into the concrete for the necessary anchorage. The inserts are made by the Truscon Steel Co., Youngstown, O., and were placed in pairs as indicated in the drawing, the pairs being spaced 4 ft. center to center along the pit walls.



Details of Bolt Insert and Manner of Application.

Data on Greasing Electric Railway Track Curves.—Interesting information on this subject is given in the October Aera. Mr. H. L. Mock, Superintendent Track and Line, International Ry. Co., Buffalo, N. Y., stated that his company cleaned and greased curves daily. This work was done by 14 men who took care of an average of 30 miles of track each. The men were paid 42½ ct. per hour and worked 10 hours per day and 7 days a week. Mr. H. W. Sanborn, Chief Engineer, Rhode Island Co., Providence, R. I., stated that on his road 27 men took care of 391 miles of track. In this instance the same men clean and oil switches as well as clean and grease curves. They average between 30 and 40 switches and 30 and 40 curves per man. Some of the curves are only greased and others are cleaned and greased. The men are paid 49.6 ct. per hour, work a 9-hour day, and 7 days per week.

Progress on the National Topographic Map, and Estimated Cost of Completion

At the recent conference in Washington of the various map-making agencies of the national Government, the two principal agencies, the U. S. Coast and Geodetic Survey and the U. S. Geological Survey, each submitted a statement of the work done to date, and an estimate of the cost of completion. This estimate is based on a 12-year program for the Geodetic Survey and a 13-year program for the Geological Survey. As is well known, the present rate of progress for either of these two surveys would mean many years' delay before the entire country is covered, but owing to the increasing demand for general utility maps, the conference in its report to the President has recommended the early completion of the work. The statement and estimate of each survey are as follows:

Basic and Primary Control Surveys of Coast and Geodetic Survey.—There now exist in the United States 16,000 miles of primary triangulation and primary traverse and 41,000 miles of primary leveling. This amount of work completes about half of what may be called the basic primary control of the country. By "basic control" is meant that minimum amount of primary triangulation and traverse and primary leveling which should be done as rapidly as is possible in order that a control point for geographic position and elevation may be available within 50 miles of any place in the United States.

To complete the remainder of the basic control will require about 17,000 miles of arcs of primary triangulation and lines of primary traverse which will cost approximately $1,275,000.

There will be required about 30,000 miles of primary leveling to complete the basic leveling of the country, that is, the network which will carry elevations over the country to such an extent that no place will be beyond 50 miles of a primary leveling bench mark. This leveling will cost appropximately $450,000.

When the triangulation and traverse have been carried to the extent indicated above, it will be necessary to have spur lines of primary triangulation and traverse carried into the intermediate areas for the purpose of furnishing geographic positions on the final datum to the topographic engineers making the standard maps of the country. This additional triangulation and traverse which will be primary in character will cost approximately $2,940,000.

Additional primary leveling will be required in the intermediate areas of the basic network of primary levels of the country in order that accurate elevations on the standard datum may be carried to the areas in which a standard topographic map is being made. It is estimated that the cost of this leveling in the intermediate areas will be $1,040,000.

The total amount of money which will be needed to furnish all of the primary horizontal and vertical control of the country, as is indicated above, is $5,705,000.

The amount of money mentioned in the preceding paragraph should be made available to the Coast and Geodetic Survey within a period of 12 years, beginning with the fiscal year 1921, in order that the primary control may be extended over the area of the country ahead of the topographic work planned by the U. S. Geological Survey which will be completed by that bureau within the next 13 years. The first year's appropriation should be about $300,000, and this amount should be increased to a maximum yearly appropriation of $700,000 for the fifth year. For three years this maximum should be appropriated and then the annual appropriation should be gradually decreased to $300,000 for the 12th year.

This primary control is not only needed by the United States Geological Survey, in making the standard topographic maps, but it should be carried on for the use of the various other Government engineering bureaus. Besides, this work will be of inestimable value to the states, cities, counties and townships in establishing forever the geographic positions of their boundary monuments, thus avoiding the very expensive litigation that is caused by inaccurate location of boundaries. In addition, the control would furnish the framework on which the railroads and highway systems of the country could be based and this, in itself would be of immense value to the nation.

After this primary control has been completed to the extent indicated above, there would be very little work, at an insignificant cost in future years in connection with primary control. This cost would simply be for the purpose of re-establishing stations that had been lost through the works of man or the forces of nature. It is possible, however, that the Coast and Geodetic Survey might, from time to time, be called on to establish secondary control in local areas for the use of other surveying and map making organizations of the Government. This would of course be in connection with revisions of the standard topographic map of the country as it develops and as changes in roads and cultural features occur, and in connection with special maps for some particular purposes.

The amount of money mentioned above, namely, $5,705,000, is for the field expenses connected with the establishment of primary control of the country. There will be needed for the pay of expert geodetic computers about $600,000 and this should be appropriated to the Coast and Geodetic Survey at the rate of about $50,000 per annum. Any unexpended balance of this money, as well as of the field expenses, should be made available until expended. It is necessarily true that, both in the field and in the office, the amount that can be efficiently spent will vary slightly from year to year, but the totals are very close to the estimates made. The amount for the computers is in addition to the regular staff of geodetic computers of this survey. Even that force, the regular staff of computers should be increased, in order that they might finally adjust the vast amount of work that was turned in by the hydrographic parties of the Coast and Geodetic Survey.

The total appropriation for field and office necessary in connection with the rapid completion of the primary control of the United States, for use by topographic engineers in completing the standard topographic map of the country is $6,305,000.

Topographical Work of U. S. Geological Survey.—On July 1, 1919, the Geological Survey had completed 42.6 per cent of the topographic map of the continental United States, exclusive of Alaska. Approximately one-fifth of this area is in need of resurvey, leaving but 35 per cent of the entire country covered by satisfactory topographic maps. At the present rate of progress, under the limited appropriations made by Congress, it will be many years before topographic maps can be made available for all sections of the country. If, however, a general policy is adopted providing for enlarging the scope of the work and pushing it forward to completion as rapidly as possible and for the expenditure of the funds herein estimated in gradually increasing annual appropriations, the present organization and technical personnel of the Geological Survey can be gradually built up so as to handle efficiently the project for completion in 13 years.

Under such a project the estimated cost of completion would be:

State.	Percentage of area mapped.	Estimated to complete.
Alabama	37	$1,158,000
Arizona	62	1,076,000
Arkansas	40	751,000
California	78	810,000
Colorado	49	580,000
Connecticut	100	....
Delaware	100	....
Dist. of Columbia	100	....
Florida	7	1,898,000
Georgia	41	1,066,000
Idaho	33	729,000
Illinois	29	811,000
Indiana	10	699,000
Iowa	21	886,000
Kansas	78	131,000
Kentucky	45	776,000
Louisiana	17	1,413,000
Maine	31	828,000
Maryland	100	....
Massachusetts	100	....
Michigan	16	1,660,000
Minnesota	9	1,896,000
Mississippi	4	1,373,000
Missouri	53	1,407,000
Montana	40	1,388,000
Nebraska	35	419,000
Nevada	46	228,000
New Hampshire	44	156,000
New Jersey	100	....
New Mexico	34	852,000
New York	91	113,000
North Carolina	36	1,244,000
North Dakota	14	648,000
Ohio	100	......
Oklahoma	57	370,000
Oregon	26	899,000
Pennsylvania	56	630,000
Rhode Island	100	......
South Carolina	38	508,000
South Dakota	25	618,000
Tennessee	50	1,087,000
Texas	28	1,560,000
Utah	82	1,041,000
Vermont	47	160,000
Virginia	83	728,000
Washington	44	587,000
West Virginia	100	154,000
Wisconsin	23	1,380,000
Wyoming	31	772,000
Total U. S.	42.6	$35,490,000
Revision, large-scale, maps, etc.		5,000,000
Total estimated for completion		$40,490,000

Under such a project the work should be expanded from year to year and would require annual appropriations, including co-operative appropriations by states, as follows:

Fiscal year.	Amount.
1919-20	$ 700,000
1920-21	1,000,000
1921-22	1,500,000
1922-23	2,000,000
1923-24	2,500,000
1924-25	3,000,000
1925-26	3,500,000
1926-27	4,000,000
1927-28	4,500,000
1928-29	4,500,000
1929-30	4,500,000
1930-31	4,500,000
1931-32	4,290,000
	$40,490,000

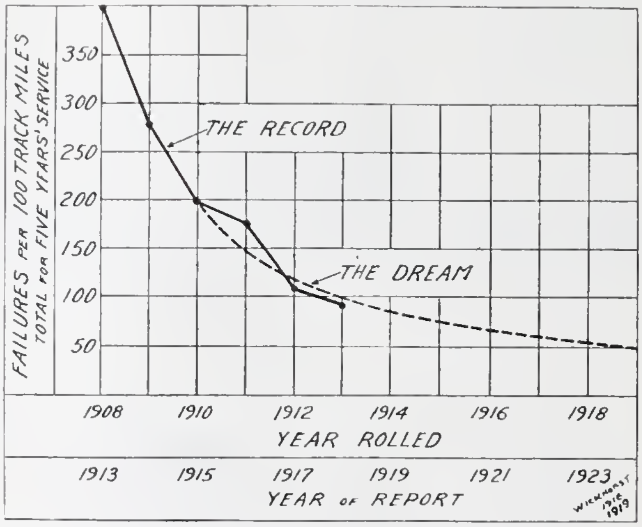
Rail Failure Statistics for 1918

Bulletin No. 218 of the American Railway Engineering Association contains a report by Mr. M. H. H. Wickhorst, Engineer of Tests for the Rail Committee, on the rail failures for the year ending Oct. 31, 1918.

The information was collected in response to a circular sent out by the American Railway Association to the railroads of the United States and Canada. The chief points of interest shown by the report are as follows:

The information furnished by each railroad showed the number of tons of each year's rolling from each mill, the equivalent number of track miles, and the total number of failures that occurred in each year's rolling from the date laid until Oct. 31, 1918.

The failures were divided into four classes, namely, head, web, base and "broken." They were reported by the railroads on American Railway Engineering Association form 408, as revised in 1915. (See Manual for 1915, page 104). The reports cover rollings for 1913 and succeeding years, and the ages of the rollings would average in track about the years shown below:



Railroad Failures in the United States and Canada.

1913	4 years
1914	4 years
1915	3 years
1916	2 years
1917	1 year
1918	several months

The tonnages represented by the statistics in this report are shown below:

Year rolled.	Bessemer.	Open-hearth.	Total.
1913	155,417	1,550,938	1,706,355
1914	59,918	1,060,763	1,120,681
1915	12,141	1,034,531	1,046,672
1916	42,399	1,191,628	1,234,027
1917	24,223	1,077,832	1,102,055
1918	12,967	470,768	483,735

The equivalent track miles are as follows:

Year rolled.	Bessemer.	Open-hearth.	Total.
1913	1,126.47	10,757.10	11,883.57
1914	429.31	7,322.96	7,752.27
1915	90.89	6,981.34	7,072.23
1916	329.83	8,017.61	8,347.44
1917	176.97	7,207.29	7,384.26
1918	94.01	3.168.42	3,262.43

Comparative performance of open-hearth and Bessemer rails are shown as follows: Figuring the failures per 100 track miles of open-hearth rails as 100 for each of the years 1913, 1914, 1915 and 1916, the relative failures of Bessemer rails, together with the failures per 100 track miles are shown below:

Year rolled.	Years' service.	Failures per 100 track miles. O. H.	Failures per 100 track miles. Bessemer.	Comparative failures. O. H.	Comparative failures. Bessemer.
1913	5	90.3	107.7	100	119
1914	4	47.4	111.1	100	234
1915	3	33.8	62.7	100	186
1916	2	27.9	41.6	100	149

The average failures per 100 track miles of the rollings for the several years, including both Bessemer and open-hearth rails, is shown in the table reprinted from Bulletin 218, as also a general diagram.

AVERAGE FAILURES PER 100 TRACK MILES.

Year rolled.	Years' service 0	1	2	3	4	5
1908	...	....	....	.....	.....	398.1
1909	...	....	....	.....	224.1	277.8
1910	...	....	....	184.0	152.7	198.5
1911	...	....	77.0	104.4	133.3	176.3

1912	...	28.9	32.1	49.3	78.9	107.1
1913	2.0	12.5	25.8	44.8	69.5	91.9
1914	1.2	8.2	19.8	32.9	50.9	.....
1915	0.7	8.9	19.0	31.2	.....	.....
1916	1.6	11.8	29.2	.....	.....	.....
1917	5.3	21.6	....	.....	.....	.....
1918	1.6	....	....	.....	.....	.....

The diagram, on which is shown a "Dream" curve, is of interest because this curve was first platted several years ago when it was hoped that it would represent future records, as indeed it seems to be doing.

Recent Tests on the Holding Power of Railroad Spikes

In a recent bulletin of the Department of Civil Engineering of Columbia University in the city of New York, some tests on railroad spikes are described which are well worth the attention of railway engineers, in that tests on spikes in wide use were tested along with a new form of spike which is claimed has some advantages over both the cut spike and the screw spike. These tests are all the more interesting because of the fact that a short time ago engineers of the Pennsylvania System made a report on the screw spike in use on their railway which was unfavorable on the whole, which was somewhat of a surprise to many in view of the high favor in which the screw spike has been held on some important railway lines.

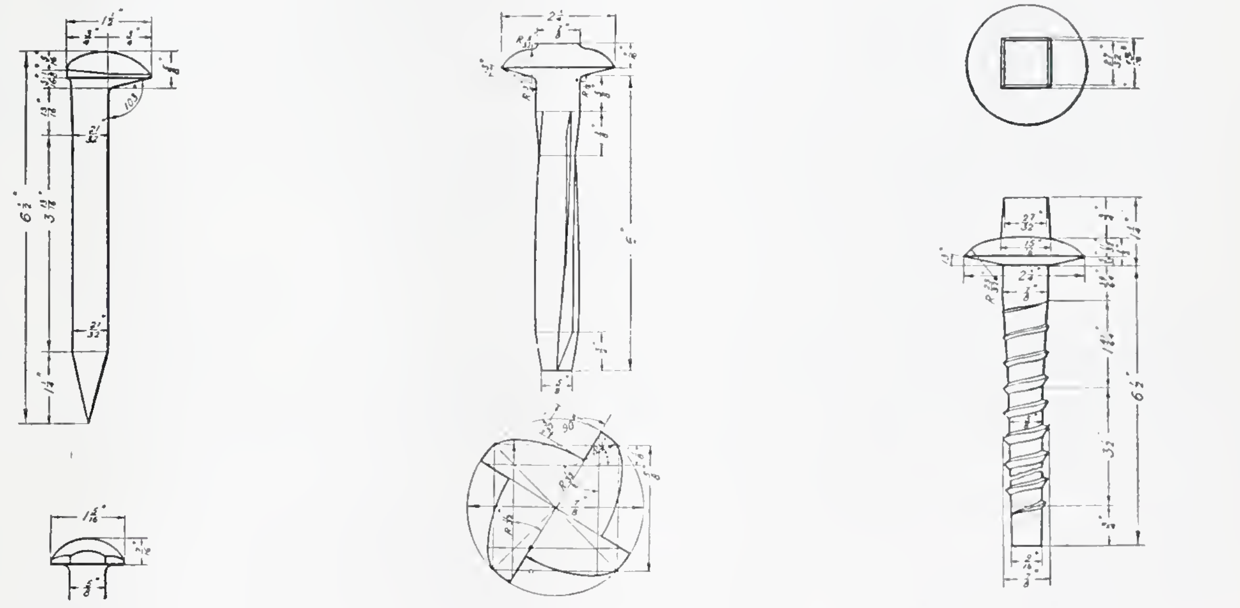
The tests were made in the testing laboratory of Columbia University by Albin H. Beyer and Wm. J. Krefeld, Associate and Instructor, respectively, in Civil Engineering.

The spikes were furnished by the various railroads, as were also the ties, which included chestnut, yellow pine, white oak, and Douglas fir, the yellow pine being creosoted, the others untreated. Details of the various spikes are shown in Fig. 1.

Methods of Making the Tests.—The tie, with the spikes to be tested facing downward, rested upon two steel blocks upon the upper head of a 100,000-lb. Riehle testing machine. The spike was gripped by means of a special holder forged in the form of a closed yoke and provided with a slot of width just sufficient to engage the shank of the spike below the head. The same holder was used for the screw and Sessler Grip spikes as they had the same sized shank under the head. The holder used for the cut spike was similar except for the slot, which was slightly narrower. The load, therefore, was applied to the spike head at two points directly opposite each other, thus tending to insure an axial pull. The lower ends, or shank, of these holders were held by the pin of a shackle which was in turn held by a yoke gripped by the wedges in the lower head of the testing machine.

The actual withdrawal of the spike was measured to the 1-1,000 part of an inch by means of a deflectometer of the lever type, one end of which was placed directly in contact with the head of the spike. Very large errors resulting from the play in the bearings of the holder, deformation of the holder proper, slippage of the holder in the wedges, and withdrawal of the wedges from the lower cross-head as they tighten on the shank of the holder, which are introduced when the withdrawal is measured by the movement of the lower cross-head of the testing machine, as has been done in many previous experiments, were thereby eliminated. This method does not, however, eliminate errors due to the compression of the wood on the cast iron bearing blocks and the twisting of the tie, especially one having a rough or warped bearing surface in contact with the bearing blocks, as the load on the spike increases.

The behavior of the various spikes was investigated for resistance to direct pull and also resistance to direct pull as affected by redriving. Two typical diagrams are shown as Figs. 2 and 3. It was in accordance with suggestions made by engineers of several of the eastern railroads that redrive and pulling tests were made to determine the effect of the successive redriving of a spike after having been withdrawn 0.25 in. It is believed that such tests will give some information as to the influence upon the holding power of the spike when redriven after having been lifted in service. Six such tests were made for each type of spike in each of the four kinds of ties.



Standard Cut Spike, Pennsylvania R.R. Lines West

Sessler Grip Spike

Delaware, Lackawanna & Western R.R. Screw Spike

Fig. 1—Details and Dimensions of Spikes Tested.

Each spike was withdrawn ¼ in., redriven or rescrewed, withdrawn again for ¼ in., again redriven and withdrawn, making three withdrawals in all. In these tests the same spikes and the same sizes of preformed holes were used as in the direct pulling tests.

Eighteen spikes were tested in each tie, as follows:

3 Pennsylvania cut spikes driven 5½ in. without bored hole;

3 Pennsylvania cut spikes driven 5½ in. into ½-in. hole;

3 D. L. & W. screw spikes screwed 6 in. into ⅝-in. hole;

3 D. L. & W. screw spikes driven into ⅝-in. hole to within 2 in. of the head and screwed to within ½-in. of the head;

3 Sessler Grip spikes driven 5½ in. without bored hole;

3 Sessler Grip spikes driven 5½ in. into 7/16-in. bored hole.

The method of testing was similar to that already described under the direct pulling tests, except that the spikes were withdrawn only ¼ in. The cut spike and the Sessler Grip spike were then redriven, and the screw spike rescrewed, the full amount of the withdrawal in all cases. The spikes were then repulled ¼ in., redriven or rescrewed, respectively, and again repulled.

Results of Tests.—The results appear to indicate that both the cut and the Sessler Grip spike develop a slightly higher initial resistance to withdrawal when driven without a prebored hole than when driven into ½-in. and 7/16-in. holes, respectively. This increases in initial holding power secured when a spike of this type is driven without preforming the hole is of doubtful value; for the efficiency and ultimate life of a spike in a tie depends not so much upon the ultimate initial resistance to withdrawal as it does upon the range of elastic behavior of the wood fibres, provided the friction between the wood fibres and the surface of the spike is sufficient.

A cut spike driven into a tie without first preforming the hole crushes and bunches the fibres over a wide area due largely to the splitting and wedging action being confined to one plane. With the Sessler Grip spike, this splitting action appears to be less, due, partly to the shape of the point tending to produce a combined cutting and splitting action, but much more to the rotation of the spike on driving, averaging 63° when driven without a hole and 68° when driven into a hole. Due to this rotation of the spike the splitting and wedging is not confined to any one plane and the accumulative effect upon the wood fibres appears to be thereby reduced.

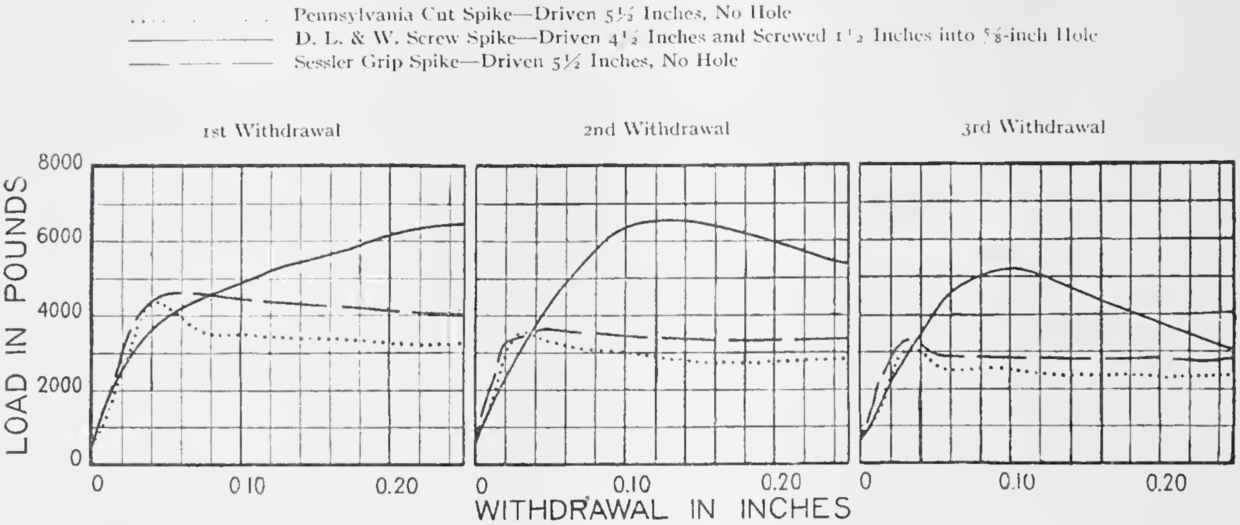


Fig. 2—Curves Showing Results of Repulling Tests from Untreated Douglas Fir Tie.

The effect upon the wood fibres of driving instead of screwing a screw spike is obvious.

The crushing and bunching of the wood fibres can be materially reduced both with the cut spike and the Sessler Grip spike by preforming the hole.

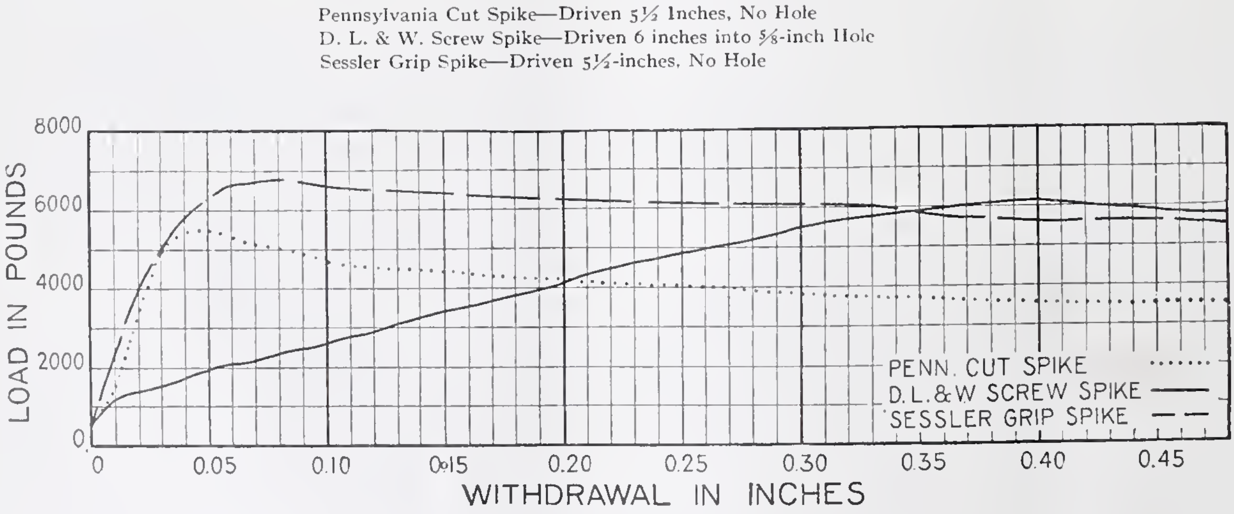


Fig. 3—Curves Showing Results of Direct Pull Tests from Untreated Chestnut Tie.

Elasticity of a Spike Fastening.—When a spike is driven into a tie the fibres of the wood are forced downward and passed simultaneously outward. When such a spike fastening is subjected to a direct pull, within its elastic range, the friction between the wood fibres and the surface of the spike tends to hold it in place and whatever yielding does take place is due solely to the elastic distortion of the wood fibres. When the load is released the elasticity of the wood fibres causes the spike to regain its original position. The elastic withdrawal limit of a spike fastening is reached either when the wood fibres in contact with the surface of the spike are strained beyond their elastic limit, or the bond or adhesion between the fibres of wood and the surface of the spike is insufficient to prevent relative motion between the two. Both in the cut and Sessler Grip spike failures appear to take place simultaneously in the two ways just described. In the screw spike, on the other hand, failure is more gradual, but incipient failures takes place at very low loads, probably due to the crushing of the fibres against the thread of the screw. At the same time, the frictional resistance between the shank of the spike and the wood fibres increases somewhat due to their displacement and the resultant failure is a very gradual one.

Within the elastic withdrawal limit the resistance to direct pull develped by a spike is directly proportional to the displacement of the spike in the wood. Also within the elastic withdrawal range the permanent set is practically negligible.

When the load upon a spike exceeds its elastic withdrawal limit sliding friction comes more and more into play and the permanent sets become appreciable.

To determine the true elastic behavior of the three types of spikes a limited number of tests were made in which the withdrawal of the spike was measured directly to the nearest 1-10,000 part of an inch. In this investigation a creosoted yellow pine tie was used and two spikes of each type were tested using prebored holes.

Based upon the results of these tests the relative average elastic limits, taking the cut spike at 100%, is:

Cut spike	100%
Screw spike	90% elastic limit in bearing 178% final yield point
Sessler Grip Spike	129%

To obtain additional data as to the elastic behavior of a spike in a tie, one spike of each type inserted in a creosoted yellow pine tie was subjected to thirty applications of loads varying between the limits of 500 and 3,000 lb. and the withdrawal and set for each load recorded. In each case the spike was subjected to an initial load of 3,000 lb. and the reading of the Ames dial when the load was reduced to 500 lb. was taken as zero set. The upper limit of 3,000 lb. was selected because this represented approximately the elastic withdrawal limit of a cut spike in such a tie.

The results showed that under thirty applications of 3,000 lb. the final set amounted to .0005 in. for the screw spike, .0011 in. for the Sessler Grip spike, and .0015 in. for the cut spike. The screw spike showed slightly lower elastic withdrawals and permanent sets than either the cut or Sessler Grip spike.

General Conclusions.—The general conclusions are set forth in the bulletin as follows:

The tests, although of limited extent, show conclusively that the rail fastenings tested act as elastic structures within certain limits, depending upon the character of the wood and type of spike.

In the softer woods the elastic limit of the fastening is reached at very small withdrawals ranging from 0.004 to 0.006 in. In an oak tie these limits appear to be somewhat higher.

Within the elastic range of the fastening the resistance developed by the fastening is directly proportional to the amount of withdrawal.

Small permanent withdrawals or sets have been recorded within the elastic range of the rail fastening but these are no greater than would be reasonably expected in a material such as wood.

A rail fastening to approach permanency must at no time be stressed beyond its elastic holding power, making due allowances for the fatigue and physical deterioration of the wood fibres during the life of the fastening.

In view of the importance of these facts to the railway profession a more complete investigation should be made to definitely establish the elastic behavior of various types of spikes, both without and with preformed holes of various sizes driven into ties of various stages of deterioration.

Cost of Making 2 In. Lift on Main Line Track

This work was done on April 9, 1917, on the Michigan Central R. R. The weather was clear and the temperature was about 50° F. A total length of 1,221 ft. of 3° curved track was lifted. In addition 62 ties were placed in track. The force was as follows:

1 foreman	$90.00 per month
1 assistant foreman	77.50 per month
1 cook	2.10 per day
1 timekeeper	75.00 per month
22 laborers	2.10 per day
1 water boy	2.10 per day
2 flagmen	2.10 per day

Of the above force the timekeeper, cook, water boy and the two flagmen are classed as "dead" labor.

The men left the bunk cars at 6:30 a. m., and began work at 7. They lifted track from 7 to 11:30, took half hour for lunch, and were engaged again from 12 to 4:30 p. m. in lifting track. They left the work at 4:30 and arrived at bunk cars at 5 p. m. It will thus be noted that the working time was 9 hours. However, there was a total delay of 40 minutes due to passing trains, which makes the actual working time 8 hours and 20 minutes.

The equipment used consisted of track tools and three hand cars.

The cost of the work was as follows:

	Per lin. ft.
Superintendency	$0.0038
Active labor	.0314
Dead labor	.0074
Delays to entire gang	.0077
Total, cost of 2-in. lift and replacing .05 of a tie	$0.0503

We are indebted to Mr. A. M. Van Auken for the above data.

Modern Requirements in a Railroad Blacksmith Shop

In a paper read before the convention of the International Railway Master Blacksmiths' Association, Mr. Geo. Fraser, smithshop foreman for the Atchison, Topeka & Santa Fe Ry., Kan., of Topeka, Kans., has outlined the present day requirements in a blacksmith shop. The following is abstracted from his paper:

From the standpoint of shop production, the blacksmith shop is looked upon a feeder for other shops of prime importance. Sometimes this is overlooked in preparing the original plans and the blacksmith foreman is not consulted, so when the shop is completed he is invited into it and it is up to him from then on to make the best of it.

The blacksmith shop at the principal shop plants of the large railway systems turn out the forgings entering into the construction of new cars, the bulk of the car forgings required in keeping up the repairs of both freight and passenger car equipment on the line, as well as the forgings for locomotive repairs. As there is a difference in the nature of the work for the two departments, each should occupy a section common to itself and the machines, forges and equipment should be arranged accordingly. Naturally the equipment for each department is to be located in that portion of the blacksmith shop nearest to the principal shop which it serves. A ground plan in the shape of an "L" is a convenient arrangement for the blacksmith shop, accessible to both the locomotive and car departments. The many conditions affecting the demands upon the blacksmith shop and the differences in the dimensions of the shops on the various railway systems render it impractical to attempt to give a definite proportion based upon any given unit.

The introduction of cast steel in many details for which forgings were formerly used almost entirely has affected the necessary size of the blacksmith shop, so far as the locomotive department is concerned, and the increased scope of forging machines, assisted by extended use of formers and dies for rapidly duplicating standard parts of cars, has increased the possible output of car forgings without enlarging the area required by the shop building.

A general practice in smith shop construction has been to span the entire floor without providing intermediate supports for the roof trusses and in a number of cases this distance is as great as 100 ft. The trusses are usually supported by the side walls which carry the weight of the roof structure and roof. While the distance from the floor to roof trusses at some of the older shops is about 20 ft., the height of the more modern shop has been increased to 30 ft.

Almost without exception, the floor of the blacksmith shop is of earth. This is frequently covered with coating of cinders well tamped and by all means should be 6 in. higher than the level of the outside surroundings.

The ventilation necessary in a blacksmith shop and the amount of natural light needed require a high free space not only to allow the smoke and gas to rise away from the floors and forges, but to permit the diffusion of light from long windows. It is a very noticeable fact that the cleanest, brightest, most airy blacksmith shops are those with high walls. The roof of the blacksmith shop is usually surmounted by a wide monitor extending nearly the entire length of the roof. This is provided for the sake of ventilation rather than to distribute light. The windows in the walls are depended upon principally for natural light and it is generally considered that the window area should equal at least 60 per cent of the wall area. In order to offer the least obstruction to the free circulation of air throughout the shop in warm weather and in warm climates the windows should be hung on pivots to provide a greater opening than raising and lowering of sashes.

In addition, the shops should be provided with rolling doors and the lay of the shop should be east and west with an open space clear from the other buildings on the south side so that all alike will share the south breeze in hot weather. An arrangement frequently followed in the construction of the monitor is to alternate the windows along the sides with space having wooden slats built in on an angle thus permitting the free circulation of air while excluding rain and snow.

The removal of smoke and gases from the forges is provided for by different methods. Experience in some shops where great care was used in their design to provide for efficient ventilation is said to have proved that smoke hoods in high shops are unnecessary and that the interior of the building is clear and free from smoke and gas at all times.

Hand forges are usually arranged in a row along the wall, placed conveniently according to the class of work which they serve. The distance between centers of forges varies from 16 to 20 ft., and 5 ft. from the wall. Forges are arranged at uniform height, about 24 in., and should be of uniform shape and size.

Careful provision for tool racks is a necessary detail not to be overlooked, for care and maintenance of tools and equipment is the duty of the energetic foreman. Tool racks are generally arranged along the wall of the shop and in the center of the shop. For hammer tools, etc., a revolving cone shape tool rack may be provided.

Oil is the most common fuel used in blacksmith shop furnaces. In latter years it has rapidly displaced coal and coke not only proving more satisfactory and economical as fuel, but it improves the appearance of the shop by removing the necessity of the unsightly coal and coke boxes about the shop. It has been demonstrated by practice that with oil as fuel it is possible to obtain a larger output, better grade of work, greater intensity of heat as well as more even heat. The elimination of the necessity of attending fires, the shortening of time required to bring the furnace to the desired working temperature and the general improvement of the conditions under which furnace men work are other important advantages. It is a noticeable fact that in a majority of the new shops, particular attention has been paid to the furnace equipment, the design of the various furnaces for the various machines and their location in relation to the machines and to the movement of the material.

The location of large scraps furnaces should be on the outside of the shop with the working side of the furnace flush with the inside of the mail wall. To avoid any possible shortage of steam, boilers should be installed over all large scrap and forging furnaces. By this plan no fuel expense is charged to produce steam as the flaming gases from the furnaces do the work.

In arranging the fires and furnaces, they should be so placed that the men are not too near a furnace or fire when working on the metal. Efficiency engineers will figure on the number of steps that can be saved in handling work from fire or furnace to hammer, or anvil, overlooking entirely the comfort of the men whose vitality is sapped out by having the fires too close to the anvil or hammer. The arrangement of furnaces, anvils, hammers and machines should be left to the judgment of a practical man, one who is acquainted with shop practice and who has had experience in charge of smith shops.

Modern machines without proper die equipment are of little value. The main blacksmith shop should be provided with its own tool room where the die work could be carried along independent of the locomotive department, thus avoiding delays. Little attention is given by other departments in assisting foreman blacksmith along these lines. The following equipment is sufficient for the average shop: One each, planer, jumper, lathe, drill press and face plate. We have this equipment in our tool room at Topeka and it greatly facilitates the work of getting out dies, etc.

In connection with furnace equipment and open fires, particular attention should be paid to the layout of blast piping. Efficient blast is a very important consideration to the blacksmith shop as it practically governs the heating capacity not only of furnaces but of the open fires. The blast line should be overhead and safety valves should be provided in the up and down lines leading to the forges to take care of any gas that may possibly enter the line. The main blast line should be reduced in area in proportion to the distance covered so as to maintain a good pressure at the end of the line. When compressed air is used in addition to a blast to atomize fuel oil, an 8-ounce blast is sufficient. When fan blast alone is used nothing short of 10 ounces will give satisfactory results.

The exhaust pipes on steam hammers should pass downward through independent pipes so as to carry the exhaust beyond the shop into a catch basin.

The modern shop may have all the facilities it is possible to provide and still may not be productive of results. The foreman in charge must have the good will and hearty cooperation of each and every man under him to reach the maximum of efficiency.

The Preparation of Data for Street Railway Rate Cases

Mr. Clarence R. Bitting of the firm of Day & Zimmerman, Consulting Engineers, Philadelphia, in a paper presented at a meeting of the Accountants' Association, has given the results of his experience in preparing and arranging data for presentation before commissions in connection with rate cases relating especially to traction companies. Some of his remarks, reprinted in the "Electric Railway Journal," we quote as follows:

The preparation of accounting and statistical data for rate cases and their presentation to public service commissions and the public are of unusual importance at this time, for practically all public utilities are so burdened by mounting costs of materials and labor that they must either receive higher rates or forego dividends to which the stockholders are entitled on their investment. The former is the fair alternative.

"A Public Utility Has No 'Fat Years.'"—In a number of recent rate cases it has been contended that a public utility should take the "lean" years along with the "fat" years, and that the stockholders should stand part of the increased cost of operation, but a public utility has no "fat" years because as soon as it is earning more than a fair return someone brings action before the regulating commission to have the rates reduced. Obviously when rates are insufficient relief should be accorded to the utilities.

A company which is capitalized 50 per cent bonds and 50 per cent stock, all of which represents tangible property, would on a 7 per cent return earn 2⅓ times its interest requirements, assuming 6 per cent interest on bonds. This would, of course, make a very salable security from a banking standpoint, but unfortunately very few companies are able, due to financial conditions, to finance their construction through the sale of stock. Of 234 companies tabulated by the writer, only 57 have preferred stock. It will, therefore, be seen that practically 80 per cent of the companies are restricted to the sale of bonds for their financial requirements. A series of calculations which the writer has prepared establishes conclusively that a company receiving a return of 8 per cent can with safety finance capital expenditures through the sale of bonds, preferred stock and common stock; at all times paying a dividend of at least 6 per cent on the common stock and still retaining a portion of its earnings in surplus to meet unforseen accidents, obsolescence and the superseding of property through improvements in the art.

Numbering and Tabulation of Data.—To begin with, a plan of numbering and indexing data and exhibits should be adopted. A plan which has been operated very successfully is based on the following main divisions:

1. Income statements by years.
2. Income statements by months.
3. Miscellaneous income statements.
4. Ways and structures.
5. Equipment.
6. Power.
7. Conducting transportation.
8. General and miscellaneous.
9. Taxes.
10. Depreciation.
11. Non-operating income.
12. Fixed charges.
13. Surplus.
14. Balance sheets.
15. Increases in wages and materials.
16. Comparisons with other companies.
17. Traffic and service statistics.
18. Estimates.
19. Investment and valuation data.

Each main account or classification should be prepared on a separate sheet or sheets of the size prescribed by the commission before which the case will be heard. In this connection it might be well to state that where an exhibit of larger size must be presented it should be prepared on a size that is a multiple of the regulation size so that it can be readily folded to such regulation size.

An idea may be formed of the subdivisions of the various main divisions by quoting from sections of index to exhibits filed in a recent rate case.

INCOME STATEMENTS BY YEARS.

1 —Chart of earnings by years.
1A —Summary of statement by years.
1A 1—Detail of revenue.
1A 2—Detail of maintenance—ways and structures.
1A 3—Detail of maintenance—equipment.
1A 4—Detail of power.
1A 5—Detail of conducting transportation.
1A 6—Detail of traffic.
1A 7—Detail of general and miscellaneous.
1A 8—Detail of taxes.
1A 9—Detail of fixed charges.
1A 10—Detail of non-operating income.
1A 11—Detail of surplus charges.
15 —Principal wage increases.

15A —Chart showing periods affected by recent wage increases.
15A 1—Chart showing hourly wage for platform employees.
15B —Statement showing cost of materials, ways and structures.
15B 1—Chart showing range of prices for rail (per ton).

For the use of a witness, it is well to have a cross-indexed copy of the exhibits for ready refernce. For instance, under "4" should be filed all of the various exhibits dealing in any way with maintenance of ways and structures.

A very satisfactory method of binding consists of the use of press boards between each of the main divisions of the exhibits and any principal or special exhibits, all to be marked with thumb tabs and bound with metal binding posts.

The preparation of accounting data showing the capitalization and capital expenditures of the company is difficult. Practically all of our traction systems are the result of a series of reorganizations, purchases, consolidations and mergers and in many cases the books of the original companies have long since been lost or destroyed through accident.

Securities issued for promotion services and discounts on bonds issued at the time of organization should be shown as separate items, also the cost of superseded property, if available, should be shown. While some opponents of increased fares hold the view that possibly excessive prices were paid for the underlying companies, a careful reading of newspaper files for a few years preceding the date of the consolidation will, in most cases, show a growing demand on the part of the public for the elimination of the disagreeable features of competitive operation of the street railway system. The only method of eliminating these disagreeable features was the consolidation of the various lines then operating, and no man was compelled to sell his property for less than his price. The public demanded consolidation and should pay the cost of same.

The estimated average depreciation for the time the property was operated by the present company should also be shown as a deduction. This statement should check in round figures with the present cost to reproduce the property and would be an additional item of proof in establishing the fair present value of the property devoted to public service.

Surveying Diamond Drill Holes

Methods of surveying diamond-drill holes are often unsatisfactory because of the limited size of the hole and by reason of the time consumed, and the results of the surveys leave a feeling of uncertainty in their wake. In a discussion of the paper, "Wedging Diamond-drill Holes," Mr. Hugh M. Roberts points out in the November Bulletin of the American Institute of Mining Engineers the desirability of devising a method of survey that would be entirely independent of the drill hole itself. He states:

The grinding of a diamond bit may be heard distinctly for long distances through solid rock, even through 100 ft. of glacial drift. Listening instruments of great accuracy have been developed in connection with underground warfare in Europe. One instrument known as the American geophone, a simplified seismograph, has been developed by the U. S. Army Engineers, and has lately been applied by the U. S. Bureau of Mines to purposes of mine rescue. Officers who have served in Canadian tunneling regiments state that the position of German headings could be determined by means of listening instruments, from the sounds of tools at work, with accuracy through chalk at distances of 1,000 ft. or more, not only as to position in azimuth but as to elevation. In a solid rock, like the norite of the Sudbury district, sound waves are transmitted distinctly. By applying the geophone to the survey of diamond-drill holes, it may be possible to fix the position of the bit while at work at various points in the hole, say every 100 ft. in depth, and thus determine quickly and with a fair degree of precision the path of the drill hole in three dimensions. The method would be particularly applicable to the survey of angle holes. These instruments are as yet in the hands of the Corps of Engineers and the Bureau of Mines. The Bureau of Mines has indicated a willingness to make tests on the application of the geophone to the survey of diamond drill holes. The results will be watched with great interest.

The First Steam Shovel.—The steam shovel, according to The Engineer, originated in England, the first one being made by Ruston, Proctor & Co.

Reforms Needed to Make Government Contracts More Equitable to Contractors[*]

When the need was for cities of soldiers where nothing but brush had existed before, the Government turned to the contractors of the country, and the cantonments were ready on time. Working under cost plus contracts, the builders made a record for speed that could have been equaled in no other way. Yet at this late day some of the claims for this work are still unsettled, and are involved in needless and seemingly endless controversies. This aftermath calls attention to the need of reform in certain features of the Government policy governing construction and serves to emphasize some of the lessons of experience gained through long contact with cost plus work. The many advantages of this method of carrying on construction should not now be lost in the confusion caused by the appearance of occasional abuses.

During the years that the Aberthaw Construction Co. has made use of the cost plus method of carrying on construction projects, a type of contract form has been developed in which as briefly and as clearly as possible we state what we are to do, how we are to be paid, and outline in some detail a few of the important features of the agreement, ending with an arbitration clause, which, as a matter of fact, is never used. On private work, where we are satisfied of the sincerity of the owner's desire to be fair, our cancellation clause is very liberal and satisfaction becomes the measure of the value of our work. But on construction for the Government, the need for adequate safeguards has been brought to mind again by the considerable volume of work done by this company during the war.

Payments on Government Contracts Unsatisfactory.—For 15 years previous to the war we did no Government work, principally because it was unsatisfactory regarding the question of payments. I feel very strongly that a radical change should be made on the question of payments, putting a penalty upon the Government for non-performance of its part of the contract. The Government and other public bodies put all kinds of safeguards against the contractor, protecting themselves against bad materials or workmanship, delays, and other contingencies, but leave the payment clause very weak with no penalties for non-performance on their part.

Our experience has been that they seldom pay as agreed. This is the life blood of the contractor and I believe that there should be sufficiently strong penalties imposed upon the Government for the non-performance of its contract to pay, such as increasing the payment and putting a penalty upon the particular officer or agent who fails to do his duty promptly, so as to guarantee that payments will come through exactly as contracted for. This is absolutely essential in order that the contractor can arrange his finances properly and not be embarrassed in the middle of his work, causing the work to go slowly, or in any other way embarrassing him so as to handicap the performance of his contract punctually.

Congress Lacks Knowledge on Cost Plus Work.—The cost-plus prejudice of Congress is largely due to lack of knowledge of contracts. If a sufficient campaign of education was instituted, not by contractors alone, but by engineers and architects as well, and they in turn arouse the interest of the general public, Congress could be made to see the wisdom of leaving the matter largely optional with the Construction Division of the various bureaus who now handle the work, which we hope later will be consolidated into a Department of Public Works.

It is the theory of the Government to give everybody a square deal. In construction work this idea should be carried out by allowing the contractor a profit on his work, but not an extravagant one. Neither should injustice be done by causing him loss. One of these alternatives is very apt to follow on a lump sum contract. It is easy to set up an organization for auditing every expenditure whatsoever and every liability incurred in behalf of a certain piece of work, as was done during the war in a most thorough and efficient manner. Thus, there is no chance for the contractor, material men or others to get more than a fair price for their work, but there is a chance for them to come out with a small profit and the Government gets full value for the money expended. I cannot see how this type of work could be handled so as to give a contractor an abnormal profit as easily as on lump sum work, where the extras can be made of an extravagant nature. With straight cost plus work, extras are put on the same basis as the regular work and nothing is concealed.

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[*] From the November Bulletin of the Associated General Contractors of America. A statement submitted to the Committee on Contracts by L. C. Wason, President of the Aberthaw Construction Co., Boston, Mass.

Must Arrange for Interpretation of Contracts.—Another essential reform in the Government's construction policy has to do with delegating authority for the interpretation of contracts. In negotiating contracts with private owners we always want to look straight into the eye of the man who is the final authority on the meaning of a contract and the interpretation of its clauses. Therefore, as far as possible all our contracts are negotiated directly with the chief executive of the corporation for whom we work.

This same idea is vital in Government contracts. Of course, we cannot always look straight into the eye of the last official who has a say upon the interpretation of the contract. The association is now in controversy with the Comptroller of the Treasury on this very subject. What we want to negotiate for and insist upon in any revision of a Government contract is that all Government heads or authorities who have any say upon the interpretation of a contract shall hereafter have that say at the time the contract is signed or before. Then the carrying out of that contract should be solely in the hands of the particular department or bureau for whom the work is being done, and the chief of that department or bureau should be the final authority to interpret the meaning of any particular phrase or paragraph.

Certainly it is decidedly unbusinesslike and unfair for the Government, long after a contract is completed, to let some particular individual who has not been a party to it, but who is yet an interested third party, interpret the contract as he sees fit when the real contracting parties have nothing to say in regard to his rulings, but must submit to them. This usually puts a great hardship upon the contractor and could be avoided if the ruling of this interested third party was had at the time or in advance of the signing, so that the contractor could execute his work with full knowledge of all conditions that were to be ultimately put upon him.

If this feature can be embodied in a contract, together with the others previously discussed, I am sure that Government work would be more desirable and sought for by contractors. This company for one would be willing to take such contracts, where now Government work is avoided where possible.

Make Payments Sure.—In contracting with private owners, or in working up a standard form of contract for general use, it is not quite so vital as with the Government to insist upon penalties in case of non-payment by the owner; nevertheless it would be a very wise safeguard to include this clause. In fact, in any standard contract which may be evolved, I think that our association should stand very firm for prompt payments and if prompt payments are not made that the owner should be penalized by an interest charge of something like 1 per cent a month. Also, some penalty should be inflicted upon the delinquent parties, i. e., the engineers or architects who fail to pass vouchers promptly. If this point can be carried through we need not worry much about the safeguards which the owner puts in for his own benefit, as we have been submitting to those for years and they can't be any worse now than they used to be.

The usual type of uniform contract drawn up to be used between architects and builders is somewhat a one-sided affair, in my opinion, as it is based on the assumption that architects are invariably honest and upright in their dealings. it has been our experience that architects do not average any better than the rest of humanity and that some of them are not fit to be trusted with such unlimited power as the contract may confer upon hem.

In these contracts their power should either be somewhat reduced or else safeguarded so that if they are found to be unjust or dishonest, as some of them unfortunately are, their contractors can get relief by appeal to higher authorities, who will either settle the matter or take it out of the hands of the unjust architect and put it into the hands of others.

Liberal Cancellation Clause.—Many minor variations have been used in the cost plus contracts under which the Aberthaw Construction Co. has worked. Perhaps the greatest variation comes in the clause as to how we shall be paid. In this there have been many different provisions, such as the sliding scale of compensation, according to the opinion of the owner after the work is completed as to whether we have given the service we contracted for or not, or the contingent profit or loss, such as half of the saving or half of the overrun on the estimates of cost made in advance.

Several variations in the cancellation clause also have been made. If we know the owner thoroughly we make this quite liberal, which serves as a guarantee of good faith on our part and saves the necessity of giving a bond. An owner wants a building erected and it has to be erected by somebody. We wish to erect the job and our only reason for so doing is the compensation to be paid us at its completion. If we give the owner satisfaction we get paid; if we do not he is at liberty to dismiss us with no complications arising on his part at any time. This puts us on our mettle to do our very best to serve the owner to his complete satisfaction. He, on the other hand, is thoroughly protected against having made a mistake in selecting us, because he can easily dismiss us if we do not do our duty. Therefore, a bond is unnecessary.

Another idea which is worth while to use and helps in financing is that on a percentage contract we will discount all bills. If the owner furnishes the money he gets the discount, but if we have to furnish the money we retain this saving. This induces the owner to pay promptly in order to secure the discount.

In conclusion, we have found the cost plus contract very satisfactory on private work, and those for whom we have done work have also been well pleased with it. There are certain reforms that are needed to make contracts, whether on the cost plus or lump sum basis, equitable to contractors and this is especially true of Government work, which is now avoided by many.

15 Hints for Care of Hoists

Hoists are built to stand hard work and hard usage; but, like all other machines, they need some attention if they are to do the best work of which they are capable, states Successful Methods. Run them to the limit of their capacity; they are built to stand it, but take decent care of them.

Boiler Hints.—(1) Firing up too rapidly when the boiler is full of cold water will result in leaky tubes and seams.

(2) Flues should be cleaned once a week or the boiler will not steam properly.

(3) Blow-off a gauge and a half of water once a day at 60 lb. pressure.

(4) Clean boiler thoroughly once in two weeks.

(5) Bad water can be partly counteracted by the addition of a pint of kerosene when filling. If no kerosene can be procured, a few potatoes will help keep the scale off the tubes.

(6) Up-and-down brace rods must not be tightened up when boiler is cold, or expansion on heating will break the rods.

(7) To prevent steaming close stack and ash-pit dampers and bank fire with green coals; in this way steam will hold for hours at a time. Don't open the fire box door to prevent steaming; the cold draught will cause leaky flues.

(8) Gauge-cocks should be tried for water before steaming up. See also that there is water in the glass.

(9) **Engine Hints.**—Cylinder cocks must be opened before starting engine after it has been standing for some time; failure to do this will result in a loose piston or the knocking out of a cylinder head. After the engine is warmed up, close the cocks.

(10) Oil the bearings and cylinders regularly; oil is cheaper than grief, and you are bound to have one or the other.

(11) Tighten bolts and nuts as soon as they begin to work loose. Do it with the wrench provided, not with a hammer or cold chisel.

(12) Open drain-cocks and drain lubricator before leaving engine at night; otherwise, in cold weather, your engine will be frozen solid when you come back in the morning.

(13) Do not alter the valve-gear on a new engine. Before leaving the shops it is set by a valve-expert to give the greatest possible efficiency and no adjustment of any kind is necessary.

(14) **Drum Hints.**—Tighten spring-bridle nuts to ⅛-in. from gear when friction is set; this will allow the drum to revolve freely on the shaft when friction is released. If this is not done, the spring bridle will cut into the drum.

(15) Grease-cups on drums are large enough to supply grease for a 10-hour run if screwed down occasionally. Be sure to fill them every day.

MANAGEMENT AND OFFICE SYSTEM

This section is published twice a month: (1) In the Waterworks and Hydraulic Monthly issue, and (2) in the Railway and Excavation Monthly issue. It covers what may be broadly termed "management engineering" as applied in the civil engineering and construction fields.

Dangerous Optimism in Business

The pessimism which expects failure is reasonably sure to have its expectations realized; but an optimism which makes one blind to unpleasant facts, or a lack of moral courage which refuses to recognize them, are commoner faults among business men, are the most frequent causes of financial disaster according to Mr. Theodore H. Price in an article entitled "Why Some Men Fail in Business" published in a past number of the American Magazine. Engineers, in common with most classes of professional men, are usually thoroughly careless of their own financial affairs, however scrupulous they may be in regard to the concerns of their clients or employers. Contractors, while less at fault, do not generally use the same business care that is exercised in well conducted commercial enterprises; and whether one be engineer, contractor or business man in other lines, he may well profit from a consideration of the causes of failure treated in Mr. Price's article. The author is known as a reorganizer of businesses, and the editor of "Commerce and Finance." He says:

"In my observation, a very large proportion of mercantile failures—meaning failures of businesses which have to do with the manufacture and distribution of goods—are due to what a professional accountant once described to me as 'hopeful inventories.'

"It had been this accountant's business to compile the schedules of bankrupts; and in that shrewd phrase, 'hopeful inventories,' he put his finger on one of the chief causes which had led to their bankruptcy.

"By it he meant that these bankrupt merchants, when they made their annual inventory, had a habit of invoicing their stocks at prices above what was then the market value of the goods. They invoiced at figures which represented the cost, plus the profit which the merchant originally hoped to obtain; not at what was the salable value of the goods at the time the inventory was made.

"This habit is not confined to men who actually reach the bankruptcy courts. It is altogether too common among business firms in general.

"Another frequent cause of failure is bad bookkeeping. I do not mean mathematically incorrect bookkeeping, but bookkeeping that is wrong in principle.

"In some of the European countries a very expressive phrase is used in this connection. When a man fails, the merchants in those countries say it was because 'he didn't keep his books,' meaning that he did not estimate correctly his overhead charges—which include many costs that are, in a sense, intangible—and that he also failed to distribute these costs correctly among the various departments of his business.

This distribution, or allocation of costs, is very important. In many establishments one department which is extremely profitable absorbs the losses in others which are unprofitable.

"From the standpoint of the business accountant or statistician, these two factors—'hopeful inventories' and 'bad bookkeeping'—are responsible for most of the mercantile failures which are not the result of what I may frankly call criminal methods.

"Among what I call immoral, or unmoral, practices which often lead to business failure, speculation takes the first place, because all business is to a greater or a less degree speculative.

"But a distinction must be drawn between legitimate and illegitimate business speculation—and it is a very fine one. The conscience of the business man himself must be his chief reliance in determining what speculations are legitimate for him, and what ones are improper and an injustice to his creditors.

"For instance, the dry-goods merchant, who must buy his autumnal stock of goods in the spring, is by the very nature of his business compelled to 'speculate' upon the demand he is likely to meet when the autumn season shall have arrived.

"It is impossible for him to know positively whether the crops which promise well in the spring will come to the hoped-for fruition. He is, however, justified in calculating at least upon an average yield. But if, in a moment of unguarded optimism, he should base his purchase upon the expectation of abnormally large crops, and then should find in October that the people in his section were impoverished by a crop failure, the probability is that he would have to face a considerable loss upon at least the seasonal portion of his stock.

"There is another form of speculation, however, concerning the impropriety of which there is a question. The man who speculates in his own business, with which he is thoroughly acquainted, and of whose risks he is entirely aware, is perhaps justified. In fact, as I have explained, he is obliged to base his advance purchases on his opinion of what the future holds.

"But the man who goes outside of his own business to speculate—the hardware dealer who speculates in cotton, the proprietor of a shoe store who speculates in grain, the dry-goods dealer who speculates in stocks—loses his credit just as soon as his speculative proclivities become known to the bankers who extend him the financial accommodation upon which he depends to supplement his own capital.

"Of course the temptation to engage in what may be called outside speculation is at times very great. Every few years there spreads over this country—and over all countries for that matter—a speculative mania, whose contagion it is very hard to resist. The conservative merchant, especially as he grows older and finds himself a little less disposed to work hard in order to keep his regular business up to the standard of his youthful efficiency, is very prone to allow himself to hope that he can increase the income he is so sorely in need of to meet the growing demands of his family by the deal in stocks, or the 'flyer' in grain, which the local broker so confidently recommends him to undertake."

Mr. Price does not overlook domestic extravagance as a cause of failure; but he departs from the hackneyed joke upon the wife's unreasonableness and places the blame more frequently upon the father's unwillingness to disappoint his children in their desires, and to admit his own seeming incompetence or mediocrity in not having the necessary funds.

Passing to more strictly business affairs, he says:

"When it comes to a consideration of the causes of failure that are within the business itself, and due to what we might call its misconduct, I should probably name as the first inability, or unwillingness, of a business man to divest himself of details and to trust to the judgment of others as his business grows larger.

"It is said that the late E. H. Harriman once entered the office of one of his managers and found the man sitting at a desk piled high with papers. He was hard at work, going over vouchers and other minor documents.

"'If I ever come here again,' said Harriman, 'and find you with your desk buried in papers, putting in your time on details like these, I'll discharge you! I can get a man for twelve hundred dollars a year to do work of that class.'

"One of the best definitions of a good executive that I have ever heard is: 'A man who decides quickly—and is right 51 per cent of the time.' Like all generalizations, this definition has the weakness of its simplicity, but it states an important truth.

"In this complex life of ours it is useless to try to look too far ahead. And the man who is not only willing to decide quickly, but who also has the ability and moral courage to change his mind and reverse himself, possesses two of the most important attributes of the business leader.

"The statisticians and professional credit men, who have to do with the study of what might be called business pathology, are, I think, rather too much disposed to try to chart the causes of business failure. I know of one credit department in which an effort has been made to establish a fixed relationship between the capital employed in a business and the volume of the business transacted. I don't think any such relationship can be established. An able man, possessing the confidence of his business associates and enjoying the credit which is a product of high character, may do a business of $1,000,000 a year on a capital of $50,000. The man without the credit which is the product, or rather the fruit, of character may find a capital of $200,000 insufficient for an annual turnover of $1,000,000.

"It is, of course, true that there are more failures among those who have a small capital than among those who have a large capital. But there are no reliable statistics showing the proportion of each class that fails. And the idea that the proportion of failures is greater among business men of small capital is, I think, a mistake entirely due to the fact that there are not many people who have large capital.

"Generally speaking, the 'small business man' is a small business man because he is unable, or unwilling, to think in a big way. But a man who conducts even a small business so that it prospers is a credit to himself and a benefit to his community. And the man who fails in a small business has as much cause to be ashamed as the one who fails in a big business.

"As a rule, the fundamental reasons for failure are the same. You may not, at first, quite understand me when I say that a lack of philosophy is at the bottom of failure. But I use the word "philosophy" in this connection in its etymological sense, which is "love of thinking."

Laziness is the quality which keeps thousands of men from business success. Not physical laziness so much as mental laziness.

"This mental laziness is probably the commonest failing among business men. It was Solomon himself that said: "Seest thou a man diligent in his business." He shall stand before kings." That bit of wisdom is just as true today as it ever was.

"I have already referred to lack of moral courage as a cause of business disaster. Sometimes it is rooted in vanity, as, for instance, in the case of men who have been regarded as the business leaders in their community. They are the ones who are always called on to head a subscription list. If a new local enterprise is started, they are expected to take stock. They think they must have a big house. Their families must live expensively. They must belong to clubs, entertain, keep plenty of servants.

"These men often try to deceive themselves about their lack of moral courage. Time and again some acquaintance has said to me, "So-and-so came to me for a subscription. I can't afford to give the money just now, but if I should refuse it would hurt my business credit.'

"Of course, they may have been sincere in some cases; but more often than not I think this was a mere subterfuge. They didn't like to give up the prestige of being 'a leading business man.' They hadn't the courage to say 'No.' Their vanity overrode their judgment."

Plain swell-head comes in for its share of criticism; and near the end of his article, Mr. Price gives the following pertinent paragraph:

"A man must realize that a business is something more than the two things—buying and selling. Between these two there is a region which, only too often, is terra incognita to the head of the establishment. In it are all the items of overhead charges; rent, heat, light, salaries, depreciation, interest charges, the cost of carrying his debtors, and the cost of being carried by his own creditors."

Polish Railway Lines Under Government Control.—It is reported by the Polish authorities that all railway lines of Poland, comprising a total of 7,110 miles, are now under the control of the Government. Of the railways thus operated, 5,606 miles are under the civil authorities and 1,504 miles under the Polish War Department.

"How We Found a Cure for Strikes"

Under this title the September number of System carries an article by Brigadier General Brice P. Disque, formerly Chief of Spruce Section, Signal Corps, U. S. A., which is so absorbingly interesting from start to finish that it is to be regretted that it cannot be reprinted here in full. General Disque says:

"We had to have Sitka spruce, fir, and cedar for the airplane factories of America, England, France and Italy. The Northwest of the United States—Oregon and Washington—was the best place on earth to get that wood. Those states had it in any quantity. To get that wood meant expanding production 2,700 per cent and several other things, among which was the building of 13 railroads.

We got the wood. In the getting we got something else which is of lasting value to the Pacific Northwest—a new working basis between the employers and the employes, which not only stood the tests of war but has to date withstood the severer tests of peace."

Referring to the traditional happy-go-lucky character of the American lumberman and his displacement by the foreigner, the article continues:

"But things, within the last dozen years, have changed to a great extent in the Northwest; the young American seldom go into the woods and the elder generation has passed on to ownership of the industry or to other occupations.

Why the Men Were More Inclined to Strike.—In their place has come a large number of foreigners, ignorant of American ideals—the same sort of men that construction gangs are recruited from—and when I went into the camps these foreigners were pretty generally being run by agitators affiliated with the I. W. W. and intent upon every form of sabotage. The operators were a hard-headed lot. Being mostly men who had risen from the ranks, who had worked 12 and 14 hours a day in order to attain their present efficiency, they had never considered any work too hard for themselves and they did not consider any work too hard for those whom they employed. They had gone through the mill and they expected others to go through it. They were fighters, every one of them. They fought to keep up prices and to beat down labor. No one had ever suggested that there might be anything in the nature of mutual obligation between employer and employe.

The employers got all that they possibly could out of the men at the lowest possible cost. The employe gave as little work as possible for the highest possible wage. They invented the lightning strike. The "struck on the job." One employer testified that often he would start the day with a full crew, and finish with no one but a cook and a dishwasher. The labor turnover ran to 1,000 per cent. The employment agencies in Spokane hired 8,000 men a month while only from 8,000 to 12,000 men were altogether employed in the district!

The General attacked the problem systematically. He says:

"A thorough investigation convinced me that practically all of the difficulties could be traced to these fundamentals:

"1. Intermittent, seasonal work.

"2. The persistent rumors that the employers were making enormous profits and gouging the Government.

"3. The lack of any means of reaching understanding between the parties.

"4. Almost indecent living conditions in the camps."

Such lack of knowledge as is mentioned in the next section would be astonishing were it not all too common in other lines as well as this. More novelty is found in the use to which the knowledge was put, once it was secured.

"Up to that time the operators in the Pacific Northwest had never known how much it cost them to cut and market lumber. They had just completed a system of uniform accounting, and when the results arrived I suggested to the employers that they take them up with committees of their employes, so that every single fact would be in the hands of the men they hired. This was revolutionary. But finally I prevailed upon them to lay them on the table. The employes went with suspicious care into all the accounts. They saw the exact relation of their wages to the profits and they also calculated how much of the profits the Government would take by taxation.

"The committees went back to their fellows with exact figures that contradicted the preachings of the I. W. W. that the employers were getting everything and the workers were getting nothing. And let me say right here in all fairness that the lumbermen of the Pacific Northwest represent one great industry which did not profiteer during the war."

The most striking feature of General Disque's work was the organization which he perfected among the men.

"We had meanwhile organized the "Loyal Legion of Loggers and Lumbermen" on a patriotic basis. The members pledged themselves to do their part in the winning of the war. In the forming of the organization, patriotism had its large part, but I am sure we should not have succeeded without the coupling of substantial justice with patriotism. Let people sit down and talk and they will find a solution for nearly anything—if only the conviction exists that both sides want to be fair."

With this thought in mind, the four conventions were held, and out of them grew the Headquarters' Council representative system.

"A delegate suggested that each nominee tell what he expected to do if elected—remember these men were supposed to be ultra-radicals. It would not have been surprising if the occasion had been taken to let off a good deal of anti-capital stuff. But nothing of the kind happened; two or three nominees started on approved I. W. W. tirades, but they did not get far—the delegates howled them down; they wanted to hear doers and not talkers. Finally they elected their representatives—Americans, who had stated the most sensible and constructive ideas on these points:

"1. To discover first if the operators were sincere in their intentions, or if there was 'a nigger in the woodpile.'

"2. The stabilization of the industry so that 12 months' work might be given.

"3. Keeping in touch with constituents so that, as representatives, they would always represent.

"The Men Justified Their Judgment. The meeting was absolutely in the hands of the men themselves; and they could have elected anarchists if they chose. But instead they elected, almost without exception, the longest-headed and most intelligently conservative of their number. They worked out the system of local and district councils, and before long I found that they were directing themselves. The broad features of the plan of self-government were:

"1. By secret ballot, representatives of each local were chosen by the employes from their fellow workers.

"2. These representatives formed a local committee which met with the manager of the local camp or mill whenever necessary with a view to reaching a fair settlement of local grievances.

"3. The local committees selected their own chairmen and these men of all local committees in each of the 12 districts selected from their number three who made up the employe representation on the District Committee; the employer representation on the committee was three employers appointed by my office.

"4. The local committees had power to settle any question arising within the jurisdiction of their local, providing the solution did not involve a violation of the general regulations of the Headquarters Council. Should the local committee be unable to come to an agreement with the local management, or should its solution involve a a violation of, or require an amendment to, the General Regulations, then the case was referred to the District Council, which in its turn might render a binding decision, or recommend to the Headquarters' Council any change in the General Regulations considered necessary.

"5. The Headquarters' Council (later the 'Board of Directors'), composed of one employer and one employe elected from each district council, resulted in an organization of 12 employers and 12 employes. This council had power to pass finally all questions and to render any decision within the limits of the general authority originally granted by uannimous action of all employers in convention . . . and the unanimous action of representatives of the employes. . . .

"6. Any individual employer or employe could at any time present his case and he had a direct and rapid line of appeal up to the Headquarters' Council.

"7. Representatives of the Spruce Production Division, stationed in each district, performed the duties of auditors and sanitary inspectors.

"8. Local secretaries, elected by their fellow employes, acted as the executives of their locals, transacted its business, and handled communications.

"The workings of these locals and councils were magnificent. We got an interest in the production which transformed an output of 23,000,000 ft. a month, only half of which was suitable for airplanes, to 23,500,000 a month of perfect stock. We had no strikes at all. Wages were adjusted from time to time according to the cost of living. Certain jobs in lumbering cannot be limited to eight hours, such as kitchen work, firemen, and those who make ready machinery; these men were exempted from the eight-hour-day rule.

"Good will developed. We did not have a Utopia, but we did have a good common-sense working basis which was not to be disturbed by idle rumors and reports—and the woods grow rumors as well as trees!

"The Armistice came and, as a war measure, the Loyal Legion was scheduled to pass out of existence. But the members thought otherwise. They would not have it die: they wanted it and in two conventions held in December, 1918, the Loyal Legion of Loggers and Lumbermen began as a peace organization, faced with the reconstruction of the lumber trade in the Northwest. They drew up a constitution and by-laws and the objects as stated in the constitution give an idea of the broad purposes which dominated:

"To maintain the basic 8-hour day.

"To ensure to the workman a just and equitable wage, and to the employer a maximum degree of efficiency.

"To standardize working and living conditions in camps and mills. To create a community spirit by the promotion of matters pertaining to public welfare, in each locality.

"To encourage, when and where it is found feasible, co-operative hospitals for the care of the sick and injured, and medical attention to the families of members.

"To co-operate with the legislative bodies of the various states for the improvement of laws relative to accident insurance and the prevention of accidents.

"To institute, when feasible, employment service.

"To further recreation and educational facilities in the camps and mills.

"To provide an organization on the basic principle of the 'Square Deal,' in which both employer and employe are eligible for membership and may meet on common ground.

"To promote closer relationship between employer and employe in the lumber industry.

"To provide means for the amicable adjustment, on an equitable basis, of all differences that may arise between employer and employe.

"To foster personal relationship and the spirit of loyalty between the employers, their representatives, and the employes.

"To provide methods of informing its members upon all questions of trade interest to operators and workmen.

"To favor the development of logged-over lands for actual settlers, upon a reasonable system of payments.

"To develop to the highest degree possible, loyalty to the United States and its laws and government, and to promote and demand proper respect for its flag.

"The District Board has both original and appellate jurisdiction. From this board there remains an appeal over the Board of Directors of the Loyal Legion, with further machinery so that an impasse is all but impossible. Here, then, we have a joint government of a large industry covering three states. What has it done?

"It has agreed upon two policies which of themselves would justify its existence and which I think are more advanced than any labor action taken anywhere:

"1. It has agreed that wages are not represented by dollars, but by purchasing power, and that as the purchasing power of the dollar increases, the wages (and the employer's profits) may go down in order to promote the public buying of lumber. Shortly after the armistice, several wage reductions took place after consultation and agreement and were accepted everywhere as fair. Since then the demand for and the price of lumber has gone up and wages have been increased.

"2. It has agreed that men shall not be discharged without cause and that it is the duty of the employer to provide continuous employment. It is recognized that, during the season when lumber cannot be cut, the wages cannot be so high as in the active time, but that jobs can be found in and about the camps doing the vast amount of repair and construction work which is always due at the end of a busy season.

"The lumbermen probably did more effective work than any other body during the war—at least I think they are the only group of war workers of any size that showed such an increased efficiency; but they are almost alone in not stopping work to talk about their achievements. It will be four or five years before the organization can be said to have been completed.

"And finally, in the state of Washington, particularly, there has been the strong opposition of the unions. During all my work I was hampered by the unions. They talked a deal about helping to win the war, but I found them much more intent upon trying to cause disturbances among the men; and to increase their own numbers and power; at no time did they put the war ahead of the union. I say this regretfully because I believe in unions, but I hold that such organization should be for the mutual benefit of the men and the employers, and that is what the unions of the Northwest are not.

"They seek through brute force to gain an advantage and I am afraid that they are riding for a hard fall just as capital had a fall when it tried to use only brute force.

"In its early struggles union labor was compelled to match force with force, and, in order to accomplish the great benefits which it has accomplished for the laboring man, it of necessity used coercion. But the times are changing and we too must develop. Prussian tactics will not solve labor problems when used either by managers or unions. They are bound to fail in our industrial world in just the same way that the Hun failed in the political world.

In the Northwest the present thought is not brute force or unfair advantage. Both sides have tried those tactics and found them worthless. The new way seems better all around."

How to Make and Apply Time Studies

The complete standardizing of operations in most cases requires the use of time studies of the work. Although many features of an operation such as layout, equipment, safety, etc., may be improved by general investigations, studies and designs, nevertheless a detailed time study is usually desirable in order to secure the maximum possible improvement and to develop incentive wage plans.

In a recent issue of 100% Magazine, Mr. A. G. Bryant, Manager Betterment Department of Joseph T. Ryerson & Co., Chicago, tells how to apply these studies and how to use the data profitably to secure more work in the same time with less effort. The matter following is taken from his article:

Time study, simply stated, is an analysis of the time required to perform the minute or sub-operations occurring in the cycle of a major job or operation. It makes possible the classification of the parts of a job and the regrouping of those parts in such a way as to make the work easier to perform, in less time.

The best methods of time study depend, of course, upon the purpose for which the study is being made. However, there are certain fundamentals in connection with this work which affect the making of the time study under any circumstances.

Many persons unacquainted with the science involved in standardizing operations feel that any person may, without previous experience, take a stop watch in hand and "make a time study." It is really only after long experience in this work that one appreciates fully the amazing intricacies involved in analyzing an operation.

There are a number of features of time study work on which fairly definite opinions have been formed by experienced engineers. With this in mind we shall attempt to set down briefly the best practice connected with the most important points, covering, roughly, the following:

1. Whom and what to study and when to do it.
2. How to approach the workman and the job when starting the study.
3. The equipment to use, including forms, watch, etc.
4. How minutely to subdivide the operations and how many observations to be taken.
5. How to analyze the study.
6. How to decide on the time actually required to perform an operation.
7. How to use the time study data for purposes of general standardization, etc.

What to Study.—There are many operations which it is foolish to analyze with time studies, because their controlling factors are not influenced in any way by the element of time; however, there are also many jobs which have been overlooked by managements as not desirable for time study application, which, nevertheless, would profit exceedingly by time studies of the right kind.

For instance, a shipper might not be able to reduce the amount of time spent at a loading door because of the uncertainty of the arrival and departure of the carriers, but a time study of that part of his time devoted to loading of wagons or cars might point out valuable improvements that could be made in this service, with a reduction of the cost of the vehicle.

Frequently the question is asked as to what man of a group working on the same operation should be made the subject of time study. For instance, if a battery of ten punch presses, producing the same article, were to be studied, it would be necessary to select some one of the operators for observation.

We believe that best practice declines to take the exceptional pace setter and also refrains from choosing a workman who is unusually slow or inefficient. That man should be studied whose record indicates that because of his ability, temperament and all other qualifications, he is the practically all-around "best man" for the job.

Pace setters are unusual and it is impossible to expect ordinary men to accomplish the extraordinary results which such men do because of uncommon qualifications.

On all classes of work there is the type of man who can be considered neither too good, nor too slow for the job, and his status should be the basis for the selection of the desirable time in which the work may be accomplished.

By this we do not mean to infer that the good points in the pace setter's make-up should not be recognized and taught to other men, if possible.

There is a difference in the time required by individuals to do a task in the different parts of a day. Most workmen slow up in the latter part of the working day on account of natural fatigue. These points should be taken into account in selecting the time for making a time study of an operation.

If it is possible at all, it is exceedingly desirable to let the time study occupy the entire working day. In this way complete information is obtained of all of the conditions entering into the work as time progresses from morning to evening.

Skid Walking Device for Land Dredges

A land dredger that is moved up to its work by skids has been employed on several drainage ditch jobs this season. Four skids are used, two on each side of the ditch, and lying longitudionally with the dredge. The main skids are directly under the outer ends of the axles of the dredge and are securely fastened to the axles which are supported above the main skids with brackets or pedestals. The main skids are long enough to project 4 ft. forward beyond the front axle of the dredge. Lying alongside the main skids are the moveable or auxiliary skids which are 10 in. x 24 in. and 22 ft. long and have a railroad steel of ample strength, 15 ft. long, securely bolted on the top. This railroad steel and the skid to which it is bolted are in reality the track, one on each side of the dredge, upon which the dredge is moved. The aux-

Land Dredge Equipped With Wilson Walking Device.

iliary skids are moved either way by means of cables which have a speed of approximately 30 ft. per minute. To operate the cables, power is taken from the machinery of the dredge at two points only. For operating the lifting levers power is transmitted from the swing shaft by means of a sprocket and chain and the same means is used to take power from the belt shaft with which to operate cables which pull the skids. Two motions are required to operate the auxiliary skids; this is accomplished by using two frictions, one of which drives a pinion and gear and the other a sprocket and chain. A pull of a lever gets one and a push on the same lever gives a reverse motion. The lifting levers have a roller at their lower end. The levers are shaped like a bell crank at the bottom and are pivoted at the angle or knee to a false axle which is attached to the main skid and the longitudinals of the dredge, secure, and at the point of the center of gravity of the dredge with all of its equipment attached, including the boom, dipper, engine and fuel so that when the levers are brought backward and down practically the entire weight of the dredge is picked up, there being left a slight advantage in weight at the back end so that the front of the dredge is raised first. The dredge is thus supported first by the false axle which in turn is lifted by the bell crank lever at the bottom of which is the steel roller bearing down on the rail on the auxiliary skid. Means are provided for pulling on the auxiliary skids in an equal manner and at an equal speed, so that the dredge is propelled forward squarely and steadily. When the dredge is moved forward the required distance the lifting levers are released and the dredge settles down on the main skids ready for excavation work. It is stated it requires about 30 seconds to make the average move-up. This walking device has been patented. It is handled by the Wilson Walker Co., 205 N. Kiesel St., Bay City, Mich.

Railway Ditching With Jordan Spreader Attachment

An extensive demonstration of the Jordan spreader ditching attachment, described in our issue of Jan. 29, 1919, was carried out recently on the Gulf, Florida & Alabama Ry.

On this railroad, where no ditches of any kind had been maintained on a considerable portion of the line, ditches were formed in open cuts, at the rate of 2½ miles of completed ditches per hour. In this case the original cross-section of roadway was about 4 in. higher than the tops of the ties, and the bottom of the completed ditch was 36 in. below the top of rail, making approximately 18 cu. ft. of material to be moved per lineal foot of ditch.

Upper View: Ditching in Deep Cuts. Lower: Forming Ditches in Open or Shallow Cuts.

Figured on a basis of $125 per day as the cost of operation of the ditcher, dirt was moved at a cost of 0.17 ct. per cubic yard, or $6.25 per mile of completed ditch on one side of the track. These costs refer to ditches formed in open cuts, i. e., cuts not over 5 or 6 ft. in depth.

In deep cuts where it was necessary that the material be moved a considerable distance to be wasted on fills, 400 ft. of completed ditch were formed in 35 minutes. The dirt in this case was moved an average distance of 250 ft. at a cost of approximately 3½ ct. per cubic yard; or at the rate of $121.44 per mile of completed ditch on one side of the track where the original level of the ground in the cuts was higher than the top of the ties. The completed ditch was 3 ft. below the top of the rail and the average amount of material moved was 18 cu. ft. per lineal foot of completed ditch.

The cost of making ditches by either of these methods will, of course, be materially reduced where ditches have already been formed and only cleaning is necessary as the amount of material to be moved will be much less. In case of a deep cut ending at a road crossing or where for other reasons it is impossible to waste the material on fills, it may be carried to piles of from 30 to 50 yd. each. It was found in the demonstration that 10 cu. yd. of material could be moved at a time without piling up in the attachment enough to foul the ballast. The ditches formed were uniform in cross-section with no loose material in the bottom to retard the flow of water.

The work on the Gulf, Florida & Alabama R. R. was done done with a Jordan spreader with ditching attachment, leased from N. K. Sneed, railroad contractor of Huntington.

A New Portable Air Compressor

A new light weight gasoline engine driven portable air compressor unit has been brought out recently by the Ingersoll-Rand Co., New York. The unit is built in two sizes, differing in respect to the location of the air reservoir and in minor detail of design, and is known as the Imperial Type 14 portable compressor.

These are all-steel outfits, from their sheet steel canopy to the broad tired steel wheels. The power plant of each consists of a duplex, vertical compressor driven, at high speed, by a four cylinder four cycle, tractor type gasoline motor. The larger machine, of 210 cu. ft. capacity, weighs only 6,000 lb. and the 118 cu. ft. unit 4,000 lb.

The compressors have cylinders cast en-bloc, with cylinder heads, valve chambers and water jackets integral. Both intake and discharge valves are of plate type and are located directly over the cylinder bore. Crank shafts and connecting rods are drop forgings. Air pistons are fitted with three piece piston rings and, in addition, with an oil wiper ring. This latter returns all surplus oil from the cylinder walls to the crank case, and is claimed to obviate the difficulty caused by having the air carry an excess of oil into the receiver. All bearings are die castings of anti-friction metal. Hand holes in the crank case permit convenient access for adjusting main bearings and those of the crank pins. All parts are lubricated by splash from an oil reservoir in the crank case.

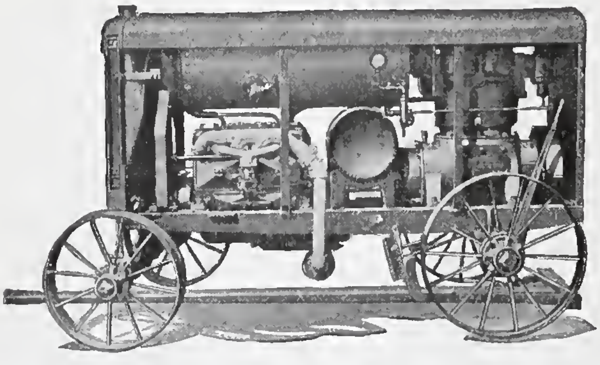
The compressors are provided with inlet unloading devices which automatically close the compressor intake when the receiver pressure rises above a predetermined limit, and permit the machine to again take up its load when the pressure has fallen a definite amount.

The gasoline driving motors are of long stroke type, and operate at medium speed. They are equipped with high tension magneto ignition with automatic governors to maintain constant speed under all working conditions and to prevent overspeeding when idling. A splash oiling system lubricates all moving parts. Starting crank is located at the front of the machine beneath the radiator.

Both compressor and driving motor are water cooled by a circulating system, with centrifugal pump, large radiator and powerful blast fan. The radiators are made up of removable sections, a construction which allows the removal and repair of a damaged section without taking down the entire radiator or interrupting the use of the compressor.

Each of these units is equipped complete with receiver, safety valve, drain valves, pressure gage and service valves to which the air hose lines may be attached. When fuel tank has been filled, lubricating oil provided and the cooling system supplied with water, the units are ready for work.

The mounting of the machines is worthy of note, particularly the swiveled front axle which moves freely in both horizontal and vertical planes. This, with the rigidly attached rear axle, gives three point suspension, and permits the outfit to pass over inequalities of the ground without any racking effect or misalignment of the power plant.



210 Cu. Ft. Imperial Type 14 Portable Compressor.

News Letter

St. Louis Items

Tom Walsh of the Walsh Construction Co. took a run into town to look over the grading they are doing for the General Motors Co. here in the western part of the city. Left here for the east.

Mulvill Bros., Alton, Ill., were awarded a small contract of grading streets for a new cemetery in Alton, Ill.

C. C. Stoner has about finished his road work near Effingham, Ill., and as soon as through is going to move on to a job stripping a gravel pit for the I. C. R. R. near Forreston, Ill.

I J. Printy reports lots of rain the past two weeks near Chatham, Ill. Everybody in the same boat in this neighborhood.

W. F. Gibson of Millport, O., and S. H. Gibson, 343 Spitzer Bldg., Toledo, O., were here last week looking up work for their team and grader outfits.

R. Condon, 3634 S. 26th St., Omaha, Neb., has some splendid team work in Iowa to sublet.

Birt & Driscoll, Decatur, Ill., want to hire a 10 or 12 team outfit with dump wagons.

A. Waddell has started on some new station work on the Rock Island R. R. between Davenport and Walcott, Ia.

W. A. Ross, 501 E. Armour Boulevard, Kansas City, Mo., has 30 good teams, wagons, wheelers, fresnos and a crusher or two idle that they would like to place on some work out in their neighborhood right away.

J. R. Scott of St. Louis was awarded contract for constructing 85 miles of asphalt surfaced road in the Tricounty Highway Improvement District, comprising Poinsett, Green and Craighead counties in Arkansas. The price has not been announced, but is said to be about $1,750,000. A $2,000,000 bond issue will be used to build the road and bridges, the latter to cost about $250,000. The Vincennes Bridge Co. was awarded the steel and concrete bridge contract.

Bernard D. Reilly, another one of our good old time railroad contractors, has passed away. Reilly died here last week at the age of 70 years from injuries suffered when he was struck by an automobile. Reilly was a pioneer railroad man in Missouri. He was born in New York but came to St. Louis when a boy, before the civil war, and engaged in railroad construction and later as a contractor. He is survived by his widow, Mary G. Reilly, two sons, John A. and Joseph W., and four daughters, Eugene, Ellen, Frances and Mrs. John E. Hanlon, and his sister, Sister Mary Xavier of the Visitation Convent at Harpersberg, W. Va.

A. B. Koenig spent last week in Omaha, Neb., where he opened a labor agency at 509 South 13th St. to look after the wants of his friends in the west. Contractors when in Omaha drop in and see B. F. Griffitts, manager there.

L. J. Smith of the L. J. Smith Construction Co., also owner of the Smith farm at Pleasant Hill, announces a two day public sale of registered Herefords to be held in the fine stock pavilion at the stock yards in Kansas City, Mo., on Friday and Saturday, Nov. 28 and 29. These dates were selected so that buyers from long distances who were en route to the International live stock exposition in Chicago the first week in December, could stop in Kansas City for the Smith sale and go on to the show. It will undoubtedly be a good arrangement for long distance visitors because they will have an opportunity to select from the 100 cows presented in this sale.

Henry J. Nicholson, 50 years old, member of the contracting firm of Ed. Peterson & Nicholson, died at his home in Omaha on Nov. 7th after an illness of only three days. Hs is survived by his wife, one son and two daughters.

J. H. McFarlin is busy with a lot of state concrete road work near Springfield, Ill. He reports the same as all contractors in Illinois, lots of rain and bad weather in the past two weeks.

E. A. Lord Construction Co., Monmouth, Ill., have an 8 team outfit that they want to place on some work in the south after Jan. 1st.

Jack Carroll reports his work at Putnam, Ill., there near completed.

A. B. KOENIG.

Personals

Col. H. M. Trippe, Whitewater, Wis., has been appointed an engineer of the State Railroad Commission of Wisconsin, and will devote his time to grade crossing questions.

Frank C. Perkins, a consulting engineer of Buffalo, N. Y., has been elected member of the board of five councilmen, who have charge of the municipal government of the city.

J. M. Clark, C. E. Krebs, G. R. Krebs, J. W. Morgan and M. M. Wagner have organized Clark & Krebs, Inc., and will carry on a civil engineering practice with offices at Charleston, W. Va.

Capt. Joseph R. Greenwood has received his discharge from the Army and has resumed his association with the firm of Charles H. Higgins, architects and engineers, 19 West 44th St., New York City.

Edward De Voe Tompkins has become associated with Thompson & Binger, Inc., engineers and contractors, 280 Madison Ave., New York City, as managing sales engineer of the New York Office. He will have direct charge of the contract department.

Garrett T. Seely, formerly assistant general manager of the Chicago Elevated Lines, has been appointed vice president and general manager of the Mahoning & Shenango Ry. & Light Co., Youngstown, O. He was graduated from the University of Illinois in 1899 and since that time has been engaged in engineering work for several steam and electric railway systems.

Joseph Jacobs, who recently returned from overseas service with the U. S. Army, has resumed his engineering practice with offices at 1317-18 Smith Bldg., Seattle, Wash. He will specialize, as heretofore, in irrigation, drainage, diking and general water supply and land development projects, public utility valuations and engineering consultation in connection with cases before the courts.

Seth Dean, drainage engineer, Glenwood; K. C. Kastberg, city engineer, Des Moines; F. W. Stubbs, mechanical engineer, Oelwein; L. M. Martin, district engineer, Iowa Highway commission, Atlantic, and Alvin Le Van, structural engineer, Ft. Dodge, have been appointed members of the state board of engineering examiners of Iowa, which will carry out the provisions of the engineers' license law passed by the last General Assembly.

George T. Slade, former vice president of the Northern Pacific R. R. Co., has gone to France to become an advisor to the French Government in rehabilitating its railway lines. During part of the war Colonel Slade was in charge of railway transportation between port of debarkation and the front. Since his return from France Colonel Slade has been making a survey of the government railroad project in Alaska and has just filed a report on his work.

Major General William M. Black, chief of army engineers, was retired Nov. 1 at his own request after more than 46 years' service. General Black was educated at Franklin and Marshall College from 1870 to 1873, entering the U. S. Military Academy in the latter year and graduating in 1877. He was made chief engineer of the U. S. Volunteers in 1898, serving one year in that capacity. He was long engaged in the work of river and harbor improvements and distinguished himself by his labors in Cuba and the Philippine Islands. He was made chief engineer of the army in 1916 and promoted to major general Oct. 8, 1917.

H. V. Latham, formerly chief engineer of the Porto Rico Irrigation Service, has been appointed chief engineer of the Isabella Irrigation Project for the construction of which the legislature of Porto Rico recently authorized a $3,000,000 bond issue. Mr. Latham has been in the service of the government of Porto Rico for the past 7 years, engaged in irrigation work and in investigations of public utility corporations. For many years he was resident engineer and assistant chief engineer of the Mexican Light & Power Co. at Necaxa, Mexico, and had previously been engaged in railroad work in Mexico and Cuba, and as U. S. junior engineer on river and harbor work in the United States.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Clamshell Buckets.—Blaw-Knox Co., Pittsburgh, Pa. Folder illustrating and describing various uses of Blaw single line buckets.

Railroad Crossings.—Alexander Railroad Crossing & Equipment Co., McCormick Bldg., Chicago. Folder describing and illustrating swing rail construction of crossing manufactured by this company.

Wagon Loager.—F. C. Austin Co., Inc., Chicago. 12 page catalog illustrating and describing wagon loader equipped with self-feeding device. Contains data on comparative costs of loading by hand and with the machine.

Pneumatic Rock Drills.—Ingersoll-Rand Co., New York. 40 page bulletin on "Little David" pneumatic drills, grinders and saws. Descriptive matter is supplemented with a number of tables giving air consumption of the various tools, etc.

Belt Conveyors and Bucket Loaders.—Barber-Greene Co., Aurora, Ill. 32 page catalog on the portable and stationary conveyors and self-feeding bucket loaders manufactured by this company. Descriptions and illustrations for various uses of the equipment are included and information is given regarding many interesting installations.

Industrial Notes

Louis J. Schneider has been appointed general sales manager of the Clark Tructractor Co., 1122 South Michigan Ave., Chicago, Ill. Mr. Schneider is a graduate of the Stevens Institute of Technology and is a member of the Society of Automotive Engineers, as well as the American Society of Mechanical Engineers. He has been closely identified for many years with the automotive industry.

Manufacturers of wood pipe upon the Pacific slope have formed the Western Wood Pipe Publicity Bureau for the dissemination of information about western wood pipe. The four companies uniting in this publicity service are the Continental Pipe Manufacturing Co. of Seattle, the American Wood Pipe Co. of Tacoma, the Pacific Tank & Pipe Co., and the Redwood Manufacturers Co., both of San Francisco. Offices of the bureau have been established in the White Building Seattle, with E. J. Bartells, manager.

Building and Structural Monthly Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field if subscribed for as a weekly at $3.00 a year; but anyone of the four special monthly issues may be subscribed for as a monthly at $1.00 a year (or any two monthly issues at $1.50 a year) and the 4 special quarterly issues will be sent without extra charge. Three of these special quarterly issues relate entirely to foreign engineering and construction practice and the fourth is our annual "New Equipment Issue." The *articles* in the first two issues of each month (1st and 2nd Wednesdays) completely cover the municipal engineering and contracting field. The *articles* in the first and last issues of each month (1st and 4th Wednesdays) completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and last issues of each month (3rd and 4th Wednesdays) completely cover steam and electric railway location, design and construction. See the "mast head" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging (c) Quarries and Pits
(b) Rivers and Canals (d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings (c) Harbor Structures
(b) Bridges (d) Miscellaneous Structures
(e) Properties of Materials

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What Is the Object of a College Education?

Several years ago Woodrow Wilson wrote an article in which he answered this query by saying: "To make leaders of men."

A. Lawrence Lowell, president of Harvard, recently gave the following as being the objects of the Harvard Engineering School:

"To train men to think; to lay a broad and deep foundation with a superstructure which can be completed only gradually from the training and observation that come from practical experience; to encourage the student to understand each problem so thoroughly that he can apply the same principles intelligently in the solution of different kinds of problems; and, finally, to train men to be good citizens as well as good engineers."

We have in these two quotations the views of two exceptionally able men who have given a great deal of thought to the problems of higher education, yet neither of them specifies what seems to us to be one of the prime objects of college education, namely to habituate men (1) to seek eagerly for useful information and (2) to apply that information. Lest it be replied that this object is necessarily involved in the general outlines given by each of the educators whom we have quoted, we purpose showing that a man may fill all their specifications yet not be habituated to seek and use information.

Taking, first, the specification that a college graduate should be trained to lead men, we all know scores of such graduates who are "leaders" but who are not habitual students of what other men have accomplished. Not long ago Frank Vanderlip, then president of the National City Bank of New York, said: "I believe we are a nation of economic illiterates. There is a science of business. It is something teachable." His wide experience as a banker in the metropolis where many of the most successful business men in America live, must have been rather disappointing, since he felt it necessary to say to a convention of executives that "we are a nation of economic illiterates." The percentage of college men as business executives is very high, yet Mr. Vanderlip did not except them from his sweeping charge of economic illiteracy.

The sale of books on any given subject can be used as a measure of the degree of literacy in the field to which the books relate. The sales of technical books invariably are much below what they would be were all technical men buyers of every book that would add to their efficiency. Even the "biggest sellers" fall lamentably short of the sales that would occur were technical illiteracy less prevalent. This illiteracy is not confined to subordinate employes; it is found among the

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

"leaders of men." Hence we say that men may be trained to become "leaders," yet lack training that habituates them to be searchers for information.

Mr. Lowell's specification is definite in so far as it calls for training men to think, but it is quite vague otherwise. A man may be trained to think, yet lack training in collecting data with which to think. There is abundant evidence that the majority of engineers are not habitual gatherers of needful data. Perhaps Mr. Lowell would reply that if this is true, the fault lies in the execution of his educational specifications and not in the specifications. To which we would reply that a vague specification usually results in an unsatisfactory product. If he regards as sufficiently specific the words "to lay a broad and deep foundation with a superstructure which can be completed only gradually from the training and observation that come from practical experience," our answer is that this leaves wide open the question of how to build the "foundation." Yet the kind of educational foundation determines whether or not an adequate superstructure will be reared upon it.

To secure the most desirable results in brain building as in house building, the specifications should be complete and definite; but it has been the custom to leave them incomplete and at least partly indefinite.

The most commonly omitted clause has been the one that should specify what is to be done to develop an insatiable thirst for knowledge. To this thirst may be attributed not only most of the great advances in science, but general progress in applying science.

The other clause that is commonly omitted from educational specifications is the one requiring the student to become habituated to applying the knowledge that he acquires through search or research. It is not enough merely to become an habitual gatherer of facts. An engineer must become an habitual user of the facts that he has gathered.

A man may be trained to think correctly along given lines, yet lack training in gathering data and in personally acting upon the inferences drawn from them.

"I Read Everything,"—Blasco-Ibanez

The great Spanish novelist, Vincente Blasco-Ibanez, now in America, is becoming the subject of many a newspaper interview. He states that it is his custom to read about six hours every day and write the larger part of his other twelve making hours. "I read everything that falls into my hands—military, science, theology, physics, anything, everything. There is nothing that does not interest me."

Those of our readers who have been interested and moved by his "Four Horsemen of the Apocalypse" (that great story of the war), his "Blood and Sand" or his "Mare Nostrum," will now better understand why Blasco-Ibanez is able to impress us with the scope of his knowledge while charming us with the beauty and veracity of his scenic descriptions and character delineations. Here is an author of wonderful imaginative power, yet given to the daily practice of seeking data with which to paint his moving pictures of men.

We have often spoken of the necessity of reading extensively in order to secure a large fund of facts with which to reason effectively. Ibanez makes it clear that he finds extensive reading equally essential in order to imagine effectively; nor is this difficult to understand when we pause to consider the processes of imaginative reasoning.

Creative thinking of every kind is imaginative thinking. This is quite as true of the invention of a machine as of the creation of an original character in a story. Imagination consists in forming new groups of ideas, the seperate elements of which are not new. Dreams are imaginative, as a rule, and not mere repicturing of any actual experiences in its entirety. A dream contains many parts of experiences—personal or by proxy—brought together in new sequence or grouping. Creative thinking differs from dreaming in that the regrouping of experiences is guided by the will.

Once this fact is clearly apprehended it is evident that a mind stored with few facts must necessarily have limited powers of original thinking; that is, limited imagination. At first sight this may seem contrary to the fact that children are so often highly imaginative, but further consideration explains this paradox.

In children experience has not yet brought many things into such frequent association as to develop a strong habit of associating those things. Lacking the habit of associating certain things, the mind of the child naturally makes all kinds of associations, incongruous as well as congruous. It sees likenesses that are often quite faint and thus brings together in its mind pictures that to an adult may seem fantastic. Note, however, that the child never imagines a single new element of his new mental picture. Always the picture is made up of elements that the child has experienced, or has been told about. The mind of the child may be very imaginative, because of lack of habitual association of things, but it is always limited in its capacity to imagine because of its relatively small stock of experiences.

Some men, partly through inheritance but largely through self-training, keep their minds in child-like fluidity, thus facilitating the association of experiences into new combinations. These men are said to be imaginative; and when their novel ideas are not so fantastic as to be unrealizable, they become practical inventors, highly skilled designers, successful novelists, essayists, poets, painters, musical composers.

With proper training, the average mind can be kept at least partly free from the bonds of habitual association of things that are frequently seen in association. Upon the extent that this can be accomplished will depend the development of the "inventive faculty." Fortunately, wide reading is an aid—although not the sole means—in keeping ideas "fluid" in the mind; while at the same time extensive reading furnishes abundant data with which to dream effectively.

"Men are such stuff as dreams are made on," because the greater part of man is his mind, and the mind is an instrument for grinding out imaginations. Unfortunately, minds are usually so ill handled that they lose most of their ability to imagine—to invent or create—and become machines for turning out replicas of old ideas, unrelieved by variety. This has come about mainly because men have been told, for immemorable ages, that invention can not be developed by training. This doctrine finds its refutation in every great creative mind, for such minds grow steadily more prolific in new ideas, if not restrained by the necessity of earning a living.

There is a vast deal of true psychology in the lines of Gray's Elegy: "Many a mute, inglorious Milton here may lie."

The Debt That Employers Owe to Society

It is one of the fundamental laws of management that employes should be paid in proportion to their performance. But how many employers are sufficiently altruistic to go beyond the letter of this law?

When employers meet to discuss wages, "piece rates," and the like, there is often an objection raised against giving the employes any payment in excess of their individual performance, on the ground that the employer is entitled to nearly all, if not all, the gain effected by the introduction of labor saving devices or methods. Indeed, we have heard it urged that since it is the brain workers who effect all improvements, to them should go the entire gain resulting from the improvements. Let us see where this line of reasoning leads.

If it were agreed that each brain worker should receive the entire saving effected by any device that he might originate, still it would be evident that the annual savings should not go to his heirs or assigns forever. Our patent law makes the life of a patent 17 years; and where no patent exists, publicity usually makes it impossible for an originator of a new idea to enjoy its full fruits for more than a very few years. Finally, even where an innovator of an economic idea is able to keep it secret for a lifetime, death ultimately forces him either to disclose the secret or carry it with him to the coffin.

Viewed in any way it is seen that there is no possibility of entailing or assigning in perpetuity the right to the sole enjoyment of all the benefit from a novel idea. It follows, therefore, that when we speak of "payment in proportion to performance" as applied to brain workers, we must mean a payment that is actually less than the full gains resulting from their performance. In other words, society in general must ultimately enjoy substantially all the gain from inventions of every sort.

Since inventors are members of society, they share with the rest of mankind the common heritage of ideas. But originating minds are peculiarly qualified to make use of this vast inheritance, only an infinitesimal fraction of which belongs to them personally. However, when any inventor adds his quota of improvement to preexisting ideas, he is prone to think that the resulting new combination is his in its entirety. He forgets that his part may be a relatively insignificant part of the new combination, and, swelled with his own conceit, believes himself much greater than he really is.

We have used an inventor as an illustration, but, with a mere change of subjects, we may apply the same conclusions to every sort of originating mind. Thus, an ingenious executive may conceive an idea that greatly reduces the cost of bookkeeping. He may thereafter be able to run his accounting department with half as many bookkeepers as before. If he is an average employer, he will not only discharge half his accounting force without a qualm of conscience, but he will not raise the salaries of the remaining force appreciably, for he will say: "Was it not my brains that wrought this entire saving? Why should I reward anyone save myself?"

In taking the entire gain for himself, at least temporarily, he may think that he is rigorously applying the rule of "payment in proportion to performance." If so, he overlooks several important factors: First, he would never have been able to make this improvement in bookkeeping had there not already been a system of bookkeeping to improve. Second, he could not have put his new plan into effect were there no trained minds to use it. Third, since most of his own education is an inheritance of ideas that have been given to him by parents, teachers, books and periodicals, he is so deeply indebted to society, present and past, that he would be a mental bankrupt were society to foreclose its mortgage upon him.

No, the employer who attempts to take, even for a short time, all the gain resulting from his own mental work, is unjustified. His debt to society can never be repaid in full. The least he can do is to share with his employes a liberal part of the gains that his brain is instrumental in effecting.

Equations for Indeterminate Structures

To the Editor: An interesting article by Mr. G. Paaswell entitled "Some Notes on Indeterminate Structures" was published in your issue of Sept. 24, 1919. Having had experience in designing indeterminate structures, I would like to make some comments on this article.

Mr. Paaswell's assumption that the frame shown in Fig. 3, when symmetrically loaded and when members are symmetrical about center line of frame, has the same moments and reactions as in frame shown in Fig. 5 is correct, since in both cases the tangent to the elastic curve at C is horizontal (in Fig. 3 due to symmetry, in Fig. 5 due to fixity of end C). Figures 3 and 5 are reproduced from Mr. Paaswell's article.

The direction of H (which is a reaction) as shown in Fig. 5 is incorrect, but this will be taken care of in the formula for H, where the sign will indicate the correctness or incorrectness of the first assumption.

In getting the work equations Mr. Paaswell obtains them in terms of H, M, V, reactions and moments at end A. He, however, later eliminates V by substituting $V = -H\frac{h}{b} + P\frac{b-a}{b}$.
This would be correct if the ends were hinged and no moments existed there; that is at A and C in Fig. 5. Then taking moments of external forces about C, we get $\Sigma M =$ $Hh - P(b-a) + Vb = 0$. From which $V = H\frac{h}{b} + P\frac{(b-a)}{b}$.
But in our case the ends A and C are fixed; moments exist there influencing the value of V. It would be as if Mr. Paaswell were to obtain reactions in a beam fixed at one end and supported at the other by ignoring the moment at the fixed end. In case the moments at the ends are equal in magnitude, but causing opposite rotation, they may be canceled. But the general case in Fig. 5 is obviously not so. The correct equation is for ΣM, $M_a - Hh - P(b-a) + Vb = M_c$. This introduces another unknown M_c (as it should).

The proper way to obtain these work equations would be not to eliminate V, but to leave it in the equations and treat it as an additional unknown.

This will cause an additional work equation; since there must be as many work equations as many unknows there are. The two work equations Mr. Paaswell has are: $\frac{\partial(\text{Work})}{\partial H} = 0$ and $\frac{\partial(\text{Work})}{\partial M} = 0$. The additional equation is $\frac{\partial(\text{Work})}{\partial V} = 0$. Using these 3 equations we obtain results which are naturally different from Mr. Paaswell's. Thus toward the bottom of the second column of page 348 of your Sept. 24 issue he gives the following values:

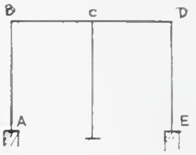


Fig. 3.

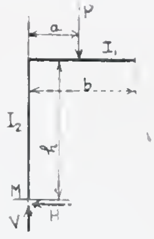


Fig. 5.

$$M = P\frac{a^2(b-a)}{b}\,\frac{I_2}{bI_2 + hI_1};\quad H = P\frac{a(b-a)(b-2a)}{bh}\,\frac{I_2}{bI_2 + hI_1};$$

The writer's values are:

$$M = P\frac{a(b-a)^2}{2b}\,\frac{I_2}{bI_2 + hI_1};\quad H = P\frac{3a(b-a)^2}{2bh}\,\frac{I_2}{bI_2 + hI_1}.$$

The writer's results check up with results of Mr. M. Abe as published in Bulletin No. 107, Engineering Experiment Station, University of Illinois, page 10, Fig. 30. Mr. Abe works out the case of a uniform load, and has a different notation. However, when the notation is transformed, the value of M at the end A agrees with the writer's value.

M. GRODSKY.

Chicago, Ill.

[The above letter was submitted to Mr. Paaswell; his reply follows.—Editor.]

To the Editor: Referring to Figs. 4 and 5 in the article under discussion, and taking moments about A and C:

$$M_a + M_c + V_c b - Pa - Hh = 0.$$
$$M_a + M_c + V_a b - P(b-a) + Hh = 0.$$

Subtracting these two equations and noting that $V_a + V_c = P$; solving for V_a gives the expression in the text.

I have carefully gone over the formulas given in my article and feel that they are correct. If the dimensions are one by one suppressed the formulas degenate into the canonical expressions for fixed beams.

The selection of the sign for the force, is, as the writer notes, a matter of indifference, the selection of an incorrect sign giving a negative value.

GEORGE PAASWELL,
Consulting Engineer.

New York.

Rules for Bolters-up.—Here are some good rules for bolters-up that embody the experiences of workers in more than one place. They are taken from "Fore and Aft":

Don't put your fingers in holes, as they might be cut off or jam in between sheets.

Don't lay a drift pin where it can roll off, as it might injure someone.

Don't lay a wrench flat. Use the sharp point and stand it in the hole when not in use.

Don't use a maul with a loose handle, as it might fly off and hurt your mate.

Quantity Survey Reduces Cost of Estimating.—The General Contractors' Association of Milwaukee, Wis., has been operating a bureau of quantity survey with excellent results. The cost of estimating has been reduced and at the same time all bidders were enabled to bid on the same basis as far as quantities were concerned.

Deductive Reasoning and Its Limitations

By HALBERT P. GILLETTE, Editor.

Because of their mathematical training, engineers have a great respect for the power of deductive reasoning; and if they have had scant training in experimental chemistry or physics, they are inclined to rely altogether too much on deduction and too little on experiment. In his "Novum Organum," Sir Francis Bacon went to an extreme in his praise of experimental methods of arriving at truth as contrasted with deductive methods. A century later Sir Isaac Newton gave a wonderful demonstration of the effectiveness of mathematical deduction in establishing the truth of the generalization that every mass attracts every other mass, a generalization destined to revolutionize not only astronomy but mechanics. As a result of Newton's grand generalization, the question began to be asked whether heat was really a "substance." If it were the substance called "phlogiston," then a body should be heavier when hot than when cold. Experiment showed that this was not so. Then it was reasoned that heat must be a mode of motion and not a substance. This conception led Joule to make his celebrated experiment that resulted in showing that 772 ft. lbs. of energy will raise the temperature of 1 lb. of water 1° F. The mechanical equivalent of heat having thus been found, it was but a step to what Herbert Spencer has called the grand unifying generalization that energy is indestructible.

I have made this introduction somewhat long in order to bring out the great value of deductive reasoning, so that when I proceed to indicate its limitations it will not be inferred that I am a Baconian in my contempt for deduction as a means of establishing new laws of nature.

What Is Deduction?—I venture that few engineers can answer this question further than to say that it consists in passing from generals to particulars, or the converse of induction. But what are the steps in the mental process of deduction? What is the distinction between the automatic deduction that all animals exhibit and the volitional deduction of which logicians treat? What is the precise distinction between the qualitative deduction that every adult, normal human being uses every day, and the quantitative deduction that is less often used? What is hypothetical deduction?

If the reader will go back over these four questions and write an answer to each of them, he will perhaps realize later on how relatively vague have been his ideas about the processes of reasoning. He may excuse this vagueness on the ground that he is accustomed to reason correctly even without understanding the theory of reasoning; and it must be conceded that in the great majority of cases correct reasoning does occur without the guidance of any theory of reasoning. Similarly, also, there were safe engineering and architectural structures before there was any theory of elasticity; but what engineer will contend that the theory of strains and stresses does not aid all structural engineers greatly in designing economic structures?

A correct and fairly complete theory of reasoning must inevitably shorten the time required to master any complex subject; and it must do more than shorten the time, it must reduce the chance of reasoning falsely. I base this statement on the fact that, other things being equal, the man who can clearly explain the causes of any phenomenon can reason more effectually about the effects that constitute that phenomenon.

Deductive reasoning is primarily a process of remembering. Remembering is a process of associating. But it does not follow that all remembering is deduction. Remembering is a word that indicates a general class of mental action, of which deducing is a subclass. To illustrate: You meet a friend with whom you played cards last night, and you instantly remember that fact and perhaps several others, by a train of association; for events are like the herd of elephants in the grand parade at the circus, each one comes in holding the next one by the tail. When you remember a casually associated fact, you are not said to deduce or infer that fact; but when you remember a fact that is invariably associated with another, you do deduce.

Take, for example, a jewel that is given to you to examine. You observe that it is translucent and refracts the light into miniature rainbows. Your instant deduction is apt to be that it is a diamond, because you associate translucency and "sparkling" with other properties that invariably coexist in the mineral called diamond. But you also remember that lead glass has these two properties, hence a doubt arises as to whether the jewel is a real or mimic diamond. You may then try to scratch glass with it, and if it scratches the glass you may class it as a diamond. As a further test you may rub the jewel briskly on the palm of your hand. If then it becomes electrified so that it will attract bits of paper, you may be almost certain that the jewel is a diamond, because, excepting the diamond, there is no known stone—natural or artificial—that has the combination of the four properties that you perceive in this stone. Having identified this stone as belonging to the class diamond, you can at once infer that it has any known property of the diamond, such as combustibility. Note, then, that in this process of qualitative deduction, you start with a known class, i. e., an invariable combination of attributes, or properties. Then you see an individual thing that you perceive to have one or more of these known attributes. This causes you to remember, or associate, certain of the other properties of the class, and to infer or deduce their "presence" in the thing you are looking at. Then, to make sure that your identification of the thing (in this case, a jewel) is one of the remembered class (in this case, diamond), you actually put the thing to a test (in this case, a hardness test); if the test shows a quality of the class, the probability that you have properly identified the thing increases. In certain cases, even one test may raise the probability to a certainty. In other cases, many tests may be needed.

The difficulty in volitional qualitative deduction lies entirely in identifying the classes to which the given thing belongs. A great deal can be said as to methods of reducing this difficulty and of expediting the operation of identification, but I reserve these matters for later articles, and pass next to a brief consideration of automatic deduction.

Automatic Deduction.—Men, in common with animals, use automatic deduction almost every instant of their waking hours. It differs only from volitional deduction in that the associations are so strong as to force an inference without any effort of the will. Thus a pigeon sees a round, yellowish object the size of a grain of corn; its mind instantly classes the object as corn, and it picks it up, only to find that its hardness and absence of a certain taste proves it not to be corn. Whereupon the object is rejected. Similarly a hunter sees certain fresh, cloven-hoof footprints in a wilderness, and instantly infers that a deer is near by. In tracking the animal, he comes upon a bush to which a bit of woolly hair is clinging, and he rejects his first conclusion. He infers the nearby presence of a sheep and not a deer. A few minutes later he sees the animal, and his last inference is confirmd by its general appearance—its other class "marks." Both in the case of the pigeon and of the man, the act of identifying the thing by some of its observed "marks" is automatic and instantaneous. In the case of the pigeon, the association of certain "marks" of food is an inherited association, called instinct. Man also has instincts, or inherited associations of class "marks." But in the above given illustration of the hunter, the associations are those acquired by personal observation so strongly and frequently impressed as to become habitual association.

In fundamental character, then, volitional deduction and automatic deduction are alike, consisting, first, in remembering the "marks" of a class; next, in identifying an individual thing as belonging to that class because it is perceived to have certain of those "marks"; and, third, in deducing any or all of the remaining "marks" of that class as being "present" in the individual under observation.

Hypothetical Deduction.—This is usually called "reasoning by analogy." I prefer, however, to give this process a name that asserts its kinship with ordinary qualitative deduction. Hypothetical deduction consists, first, in tentatively identifying a thing as belonging in a given class (that is in guessing that it belongs to the given class); second, in testing the truth of the assumption; and, third, in inferring any or all other "marks" of the class not thus tested. Every questionable identification of an individual thing as belonging to a given class involves hypothetical deduction. Uncertainty of identification is very common. Men are almost constantly placing things in a given class tentatively, or hypothetically. The illustration of the jewel, as above given, serves to indicate hypothetical deduction, up to the point that the identification is established.

The term hypothetical deduction perhaps should be reserved for the cases where more than a normal amount of imagination is required to perceive any identity at all. Thus when Newton guessed that the motion of the moon had in it an element of identity with the fall of an apple, he took the first two steps in a hypothetical deduction. The first step was the general idea that all bodies near the earth tend to fall to the earth. The second step was the tentative assumption that the moon was "near" the earth, that is near enough to be an individual instance of the general class of phenomena known as terrestial gravitation. The third step was to infer the consequences, if this were true, and the last step was to "test" the truth of the inference by its correspondence with known or ascertainable facts.

Wherever you reason that because two things are similar in certain observed respects they may be similar in certain unobserved respects, the logicians tell you that you are reasoning by analogy, and they warn you against the danger of error in this sort of inference. Although the chances of error are great, the gain in knowledge justifies many an error in arriving finally at a new truth.

Once it is clearly seen that the process of classification is the fundamental process of deductive and inductive reasoning, much of the mystery of reasoning vanishes. Then when it is seen that induction and deduction are co-ordinate processes, more of the mystery vanishes. Still there will remain one great mystery, namely, the wonderful accuracy of mathematical deduction as contrasted with ordinary deduction. Aristotle vainly strove to reduce qualitative deduction to the certainty of quantitive deduction. Modern logicians have seen the difficulty with greater clearness, but I have yet to read the works of any logician who seemed to have completely perceived the distinction between qualitative and quantitative deduction.

Quantitative Deduction.—Mathematical or quantitative deduction is qualitative deduction plus an added characteristic, namely, that after having identified a given expression as being an equation or an inequation, it is "combined" with another equation or inequation. In the case of qualitative or ordinary deduction the difficulty ends when the given individual thing has been identified as belonging to a given class, for it is then instantly known to have all the "marks" of that class. But in the case of mathematical deduction the work is not ended with the identification of equations as such, for there must follow the actual "combination" of the given equations or inequations. This "combination" may be performed mechanically, but it must be performed to complete the deductive inference, and the performance may involve much work.

The broad generalization for deductive reasoning is this: An equation is an expression of identity as to the number in two groups of things, and every equation has the attribute of being combinable with any other equation, the combination consisting in adding, subtracting, multiplying or dividing the two equations, member by member. This is the broad "class" generalization as to equations. Only one "mark" is needed to identify a mathematical expression as belonging to the class of things known as an equation, namely, the numerical identity of two groups of numbers. This, it will be noted, is in strong contrast to qualitative deduction, both in respect of the fewness of the "marks" needed for identification, and in the ease of verifying the existence of the "marks." Anyone who can count can quickly learn how to determine whether a given expression is an equation or not, he can repeatedly and quickly check himself, and he can be checked by anyone else of equal ability at counting. So the process of identifying an equation is so simple as to be susceptible of the highest possible degree of certitude. Contrast this "certainty" of identification with that involved in most instances of ordinary qualitative deduction. Take, for instance, any of the numerous black minerals, particularly when there are no visible crystals but only a mass of particles. A skilled mineralogist often finds it necessary to submit such a mineral to several tests before he can identify it, and even then he may err. But once he has surely "determined" the mineral, any known "mark" is instantly inferable.

Having established that two mathematical expressions are equations, it remains to combine them, and this usually is a relatively simple process. What then is the difficult part about mathematical or quantitative deduction? It lies entirely either in framing one or more equations to express the given conditions, or in selecting (out of all possible equations) the particular two or more that should be combined to secure the quantitative relationship that is in question.

It is very important to understand these distinctions between qualitative and quantitative deduction, for once they are perceived it becomes relatively easy to see why a person may be very proficient in one type of deductive reasoning and relatively inefficient in the other. An engineer, for example, may be an adept in solving complex hydraulic problems, yet unable to tell whether a given specimen of water is fit to drink. He may be able to solve the "pons asinorum" of geometry twenty years after he first learned the solution, yet be unable to deduct in an acquaintance a streak of egotism that his wife infers almost immediately. In his ignorance of the nature of the different processes of reasoning, a man is apt to call his wife's deductions by the name of "intuition," and imagine that "intuition" is not a form of reasoning. "Intuition" is nothing else than automatic deduction based on generalized experiences.

Limitations of Deduction.—One of the limitations of deductive reasoning is the necessarily limited knowledge of every reasoner, particularly as relates to facts outside his special field of observation and study. It may be said that this is not a limitation of the deductive process but rather of each particular mind. This may be granted as being technically correct, but for practical purposes we are concerned only with the results of deduction, and the results are certainly affected by every limitation of the thinking organ—the mind.

The average educated man regards himself as able to think correctly on any subject, provided only he is given time to learn the symbols—the names and terms—particularly relating to that subject, plus enough time to gather and analyze some of the data. The average man does not realize that it is usually insufficient to have only a moderate quantity of data at hand; nor has he studied mental processes sufficiently to understand that it takes a long time to train the mind to observe minor distinctions and remember them after they are perceived. Yet it is these so-called minor distinctions that constitute the differences between classes and subclasses. Without a very thorough understanding of all the known classes and subclasses of things in any branch of knowledge, qualitative deduction in that branch is apt to be erroneous.

Psychologists are unanimous in stating that a memory trained to record facts of one class has to be trained anew to record facts of a radically different class. There is no such thing as developing a general memory for all classes of things. Without a memory well stored with facts relating to the thing that is being reasoned about deductively, there is greater risk of reasoning erroneously. Failure to know this fact and to understand the processes of reasoning is one cause of the conceit of the average college graduate and, in general, of the average man who regards his mind as being well trained. It leads lawyers to underestimate the difficulties involved in solving economic problems. It leads engineers to belittle the work of practical psychologists, such as salesmen. Everywhere we see the evil effects of a conceit that is born of lack of understanding of the limitations of deductive reasoning.

Mathematical deduction is entirely free from the limitations of qualitative deduction, but it has many others, such as the difficulty of measuring the known forces that coact in a given phenomenon.

Every kind of deduction relating to natural phenomena is limited by the ability to perceive all the coacting forces. If any important force is overlooked, the deduced conclusion may be disastrously erroneous.

Every kind of deduction is strictly limited to what can be conceived. Whatever is inconceivable is not susceptible of classification, or of enumeration, and cannot be reasoned about. Even when engineers and scientists think they are reasoning about the inconceivably great (infinite) or the inconceivably small (infinitesimal); they are actually reasoning with conceivables if they are reasoning at all. This is not apparent to most mathematicians because they have never fully learned what the process of conception is. I reserve for a later article a discussion of conception and of the real significance of mathematical infinites and infinitesimals, with which is involved the explanation of such geometrical paradoxes as the common definitions of points, lines and surfaces. How can we reason about a line devoid of breadth and thickness? My answer is that we do not. We really ignore the literal wording of our definition of a line.

Average Weights of Various Species of Wood

In making the weight determinations given in the following table, the U. S. Forest Products Laboratory used small, clear specimens secured from the top 4 ft. of the 16-ft. butt logs of typical trees. Wood thus selected probably averages a trifle heavier than the wood in ordinary ties, structural timbers, poles, and posts. Such large pieces usually include the pith, or are taken from top logs where relatively light weight material is frequently encountered. It should be noted that any individual lot of timber in the condition specified in the column headings of the table would probably vary 5 per cent from the figures given with a possible variation of as much as 20 per cent. Young, thrifty pines, for instance, will have a high moisture content when freshly cut and probably will weigh 20 per cent above the average given.

Species and Locality		Weights		
		Kiln-dry (1)	Air-dry (2)	Green (3)
		Pounds per cubic foot		
HARDWOODS				
Alder, red	Snohomish Co., Wash.	27	28	46
Ash, Biltmore	Overton Co., Tenn.	38	39	45
" black	Ontonagon Co., Mich.	34	36	53
" "	Marathon Co., Wis.	34	35	52
" blue	Bourbon Co., Ky.	39	41	46
" green	Richland Parish, La.	38	39	47
" "	New Madrid Co., Mo.	40	42	49
" Oregon	Lane Co., Oregon	37	39	46
" pumpkin	New Madrid Co., Mo.	36	37	46
" white	Stone Co., Ark.	41	42	47
" "	Oswego Co., N. Y.	44	46	51
" "	Pocahontas Co., W. Va.	37	38	46
Aspen	Rusk Co., Wis.	26	27	47
" largetooth	Sauk Co., Wis.	26	27	43
Basswood	Potter Co., Pa.	26	27	41
"	Marathon Co., Wis.	24	25	41
Beech	Hendricks Co., Ind.	43	45	56
"	Potter Co., Pa.	41	43	54
Birch, paper	Rusk Co., Wis.	37	38	61
" , sweet	Potter Co., Pa.	45	47	59
" , yellow	" " "	43	45	56
" "	Marathon Co., Wis.	43	44	59
Buckeye, yellow	Sevier Co., Tenn.	24	25	49
Buckthorn, cascara	Lane Co., Oregon	35	36	50
Butternut	Sauk Co., Wis.	26	26	45
	Sevier Co., Tenn.	27	29	47
Cherry, black	Potter Co., Pa.	34	36	46
" wild red	Sevier Co., Tenn.	27	28	33
Chestnut	Baltimore Co., Md.	29	30	53
"	Sevier Co., Tenn.	29	30	56
Chinquapin, western	Lane Co., Oregon	31	32	61
Cottonwood	Pemiscot Co., Mo.	28	29	49
" , black	Snohomish Co., Wash.	23	24	46
Cucumber tree	Sevier Co., Tenn.	33	34	50
Dogwood (flowering	" " "	52	54	65
" western	Lane Co., Oregon	45	47	66
Elder, pale	Douglas Co., Oregon	36	37	66
Elm, cork	Marathon Co., Wis.	43	44	63
" "	Rusk Co., Wis.	43	45	54
" slippery	Hendricks Co., Ind.	42	43	53
" "	Sauk Co., Wis.	36	37	56
" white	Potter Co., Pa.	33	35	53
" "	Marathon Co., Wis.	32	33	46
Greenheart	S. A.	60	62	72
Gum, black	Sevier Co., Tenn.	35	36	45
" blue	Alameda Co., Cal.	52	54	70
" red	New Madrid Co., Mo.	--	36	46
" "	Pemiscot Co., Mo.	34	36	54
Hackberry	Hendricks Co., Ind.	38	39	47
"	Sauk Co., Wis.	36	38	51
Haw, pear	" " "	47	49	63
Hickory, big shellbark	Sardis, Miss.	47	49	62
" " "	Napoleon, Ohio	56	57	65
" bitternut	" "	47	49	64
" mockernut	Sardis, Miss.	47	49	62
" "	Chester Co., Pa.	53	55	65
" "	Webster Co., W. Va.	--	--	62
" nutmeg	Sardis, Miss.	42	43	61
" pignut	" "	48	50	62
" "	Napoleon, Ohio	51	53	64
" "	Chester Co., Pa.	52	54	65
" "	Webster Co., W. Va.	55	57	63
" shagbark	Sardis, Miss.	47	49	63
" "	Napoleon, Ohio	51	54	64
" "	Chester Co., Pa.	45	47	63
" "	Webster Co., W. Va.	50	52	65
" water	Sardis, Miss.	44	46	69
Holly, American	Sevier Co., Tenn.	39	40	67
Hornbeam	Rusk Co., Wis.	35	36	60
Laurel, California	Douglas Co., Oregon	38	39	54
" mountain	Sevier Co., Tenn.	47	49	62
Locust, black	" " "	48	49	58
" honey	Hendricks Co., Ind.	49	51	65
" "	Pemiscot Co., Mo.	42	44	60
Madrona	Butte Co., Cal.	42	43	66
"	Douglas Co., Oregon	46	48	59
Maple, Oregon	Snohomish Co., Wash.	32	34	47
" red	Marathon Co., Wis.	37	38	54
" "	Potter Co., Pa.	34	36	49
" silver	Sauk Co., Wis.	32	34	46
" sugar	Hendricks Co., Ind.	41	43	54
" "	Potter Co., Pa.	42	44	[illegible]
" "	Marathon Co., Wis.	42	44	56
Magnolia (evergreen)	Winn Parish, La.	34	35	62
Oak, bur	Sauk Co., Wis.	43	45	61
" California black	Butte Co., Cal.	37	39	64
" " "	Douglas Co., Oregon	39	40	68
" canyon live	Butte Co., Cal.	54	66	71
" chestnut	Sevier Co., Tenn.	45	46	62
" cow	Winn Parish, La.	48	50	65
" laurel	" " "	45	47	65
" Pacific post	Douglas Co., Oregon	48	50	69
" post	Stone Co., Ark.	46	47	60
" "	Winn Parish, La.	47	49	66
" red	Stone Co., Ark.	43	45	[illegible]
" "	Hendricks Co., Ind.	42	44	64
" "	Richland Parish, La.	48	50	67
" "	Sevier Co., Tenn.	41	42	61
" Spanish (lowland	Winn Parish, La.	47	49	67
" " (highland	" " "	40	42	62
" swamp white	Hendricks Co., Ind.	50	52	69

Species and Locality		Weights		
		Kiln-dry (1)	Air-dry (2)	Green (3)
		Pounds per cubic foot		
HARDWOODS (Cont.)				
Oak, tanbark	Willits, Cal.	45	44	66
Oak, water	Winn Parish, La.	45	46	63
" white	Stone Co., Ark.	46	48	59
" "	Hendricks Co., Ind.	46	47	61
" "	Richland Par., La.	46	48	67
" "	Winn Parish, La.	46	47	63
" willow	" " "	45	46	67
" yellow	Stone Co., Ark.	45	46	63
" "	Marathon Co., Wis.	40	42	62
Osage orange	Morgan Co., Ind.	54	56	62
Pecan (hickory)	Pemiscot Co., Mo.	45	47	61
Persimmon	" " "	51	53	63
Rhododendron, great	Sevier Co., Tenn.	39	40	62
Sassafras	" " "	31	32	44
Serviceberry	" "	52	54	61
Silverbell tree	" " "	31	32	44
Sourwood	" " "	39	40	55
Sugarberry	Pemiscot Co., Mo.	35	36	45
Sumach, staghorn	Sauk Co., Wis.	32	34	41
Sycamore	Hendricks Co., Ind.	34	36	51
	Sevier Co., Tenn.	35	36	55
Tulip tree	" " "	27	28	38
Tupelo	St. John the Baptist Parish, La.	36	37	56
Umbrella, Fraser	Sevier Co., Tenn.	30	31	47
Walnut, black	Kentucky	37	39	58
Willow, western black	Douglas Co., Oregon	30	31	51
" black	Sauk Co., Wis.	26	26	31
" "	Pemiscot Co., Mo.	26	27	47
Witch hazel	Sevier Co., Tenn.	45	46	59
CONIFERS				
Cedar, incense	Lane Co., Oregon	23	24	49
" "	Weed, Cal.	--	--	41
" Port Orford	Douglas Co., Oregon	30	31	39
" western red	Missoula Co., Mont.	21	22	24
" " "	Snohomish Co., Wash.	23	24	50
" white	Shawano Co., Wis.	21	21	28
Cypress, bald	Pemiscot Co., Mo.	28	29	47
" "	St. John the Baptist Parish, La.	33	34	51
" yellow	Lane Co., Oregon	28	29	56
Douglas fir	Plumas Co., Cal.	30	31	40
" "	Humboldt Co., Cal.	32	33	40
" "	Johnson Co., Wyo.	31	32	34
" "	Lane Co., Oregon	35	36	39
" "	Chehalis Co., Wash.	31	32	36
" "	Lewis Co., Wash.	35	37	41
" "	Washington and Oregon			37
" "	Missoula Co., Mont.	28	29	35
Fir, amabilis	Dee, Oregon	--	--	52
" "	Snohomish Co., Wash.	26	27	36
" Alpine	Grand Co., Colo.	22	23	28
" balsam	Rusk Co., Wis.	24	25	45
" grand	Missoula Co., Mont.	28	29	37
" "	Douglas Co., Oregon	26	27	52
" noble	Multnomah Co., Oregon	27	28	31
" white	Madera Co., Cal.	25	26	56
Hemlock	Sevier Co., Tenn.	31	32	48
	Marathon Co., Wis.	24	26	49
" black	Missoula Co., Mont.	30	32	48
" western	Chehalis Co., Wash.	28	29	41
" "	Grey's Harbor & Buckley, Wash.	30	31	40
Larch, western	Missoula Co., Mont.	37	39	51
" "	Stevens Co., Wash.	33	34	42
Pine, Cuban	Nassau Co., Fla.	43	48	53
" jack	Barron Co., Wis.	29	30	50
" Jeffrey	Plumas Co., Cal.	27	28	47
" loblolly	Nassau Co., Fla.	37	39	54
" lodgepole	Grand Co., Colo.	27	28	38
" "	Gallatin Co., Mont.	27	28	47
" "	Granite Co., Mont.	29	30	41
" "	Jefferson Co., Mont.	28	29	39
" "	Johnson Co., Wyo.	27	28	37
" longleaf	Nassau Co., Fla.	42	44	51
" "	Bogalusa, La.	41	42	56
" "	Lake Charles, La.	42	43	48
" "	Tangipahoa Parish, La.	39	41	54
" "	Hattiesburg, Miss.	38	40	42
" pitch	Sevier Co., Tenn.	35	36	54
" pond	Nassau Co., Fla.	38	40	49
" Norway	Shawano Co., Wis.	32	34	42
" shortleaf	Malvern, Ark.	35	36	45
" "	Bogalusa, La.	38	39	56
" sugar	Madera Co., Cal.	26	27	50
" Table-Mountain	Sevier Co., Tenn.	36	37	54
" western white	Missoula Co., Mont.	29	30	39
" " yellow	Coconino Co., Arizona	25	26	44
" " "	Madera Co., Cal.	28	29	53
" " "	Douglas Co., Colo.	28	29	49
" " "	Stevens Co., Wash.	--	--	56
" " "	Missoula Co., Mont.	27	28	51
" white	Shawano Co., Wis.	26	27	39
Redwood	Humboldt Co., Cal.	23	24	38
"	Mendocino Co., Cal.	26	27	39
Spruce, Engelmann	San Miguel Co., Colo.	22	23	40
" "	Grand Co., Colo.	24	25	30
" red	Coos Co., N. H.	28	29	32
" "	Sevier Co., Tenn.	27	28	36
" Sitka	Chehalis Co., Wash.	26	26	33
" white	Coos Co., N. H.	25	26	28
" "	Rusk Co., Wis.	29	30	36
Tamarack	Shawano Co., Wis.	37	38	47
Yew, western	Snohomish Co., Wash.	43	45	54

AVERAGE WEIGHTS OF VARIOUS SPECIES OF WOOD.

(1) About 8 per cent moisture.

(2) About 12 or 15 per cent moisture. Average condition reached without artificial heating by material sheltered from precipitation. North central states.

(3) Average green material.

Any individual lot of lumber in the condition specified in the column headings would probably vary 5 per cent from the figures given with a possible variation of as much as 20 per cent. For example, young, thrifty pines will have as high moisture content when freshly cut and will probably weigh 20 per cent above the average given.

Electrolysis of Concrete

The Bureau of Standards has recently published, in Technologic Paper, No. 18, the results of long time tests of the effect of electric current on concrete reinforced with steel. They show that with reinforcing iron anode at very low current densities, rusting of iron and cracking of concrete eventually occur, although the damage may not be evident until a lapse of from 4 to 8 years. The cathode effects noted in former tests showed no progress. For the benefit of engineers who may have forgotten some of their knowledge of electricity it may be stated that when the current of electricity flows from the iron to the concrete the iron is anode, and when the current flows from the concrete to the iron, the iron is cathode. The type of specimen and the method of making connections is illustrated in Figs. 1 and 2.

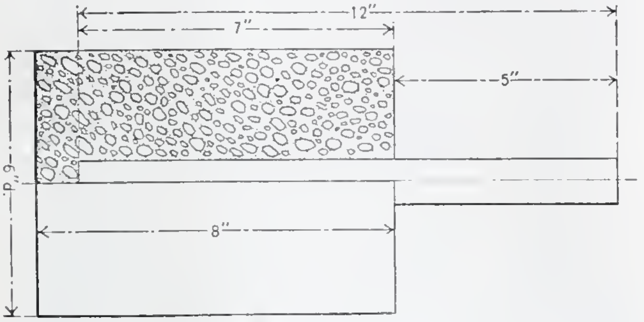


Fig. 1—General Type of Specimen Used in Electrolysis Tests.

Figure 3 illustrates the effect of a high voltage with the iron as anode. Figure 4 illustrates the softening of the concrete near the cathode. By trying specimens of concrete from which the sodium and potassium salts were removed by electrolysis, it was proven that the disintegration of the mortar at the cathode is due to an accumulation there of sodium and potassium by the current and there appears to be a consequent liberation of them of the silicates and aluminates of the set cement with a formation of soluble products. It was obvious that this action would continue until all of the sodium and potassium in the path of the current had been drawn to the cathode. On the other hand, cement free from any appreciable quantities of sodium and potassium would not show the disintegration at the cathode.

The cause of the cracking of concrete with the iron anode was investigated thoroughly. Yielding cylinders used instead of solid steel or iron, developed no cracks in the concrete, and proved conclusively that an interior pressure was developed. The physicists even went so far as to measure these pressures.

Incidently a method of cleaning iron from rust was developed. Attempts toward reducing the efficiency of corrosion by chemical means met with very indifferent success. Painting or otherwise treating the iron before embedding it in the concrete has not as yet been tried thoroughly, the tests being held up to await the outcome of some experiments with a large number of preservative paints for iron as preventives of natural and electrolytic corrosion in the presence of air and moisture.

The judicious distribution about a structure of courses of masonry or concrete of high specific resistance offers large possibilities as a contributory means at least toward minimizing electrolysis in reinforced concrete in those cases where electrolysis might be expected to occur. Investigations were accordingly undertaken to ascertain the specific resistance of very wet concrete of different proportions, methods by means of which its specific resistance might be increased, and also the specific resistances of samples of the two commonly used building materials, granite and limestone, in both wet and dry condition. In a search for an effective and durable insulating coating which might be applied to the surface of concrete some tests were made of a number of waterproofing and damp-proofing paints and membranes.

Possibilities of Trouble from Electrolysis in Concrete Structures Under Practical Conditions.—The matter has been studied from the practical standpoint also, in order to determine, as far as possible, to what extent the conditions under which concrete can be injured in the laboratory may be expected to obtain in practice.

A careful study of the data shows conclusively that while there are conditions under which reinforced concrete may be seriously injured, such conditions are nevertheless exceptional rather than the rule. These exceptional conditions occur, however, with sufficient frequency to make the problem one of great importance, and fortunately most of these conditions are amenable to control. It has been seen that the most important essentials to the injury of concrete by electrolysis are moisture and a difference of potential between electrodes in contact with the mass of the concrete. At first thought it might appear that these two conditions are almost omnipresent, since perfectly dry concrete, especially below grade, is seldom if ever found; while as every electrical engineer knows, there are few places in our cities at the present time where appreciable differences of potential can not be found between any two points more than a few yards apart. The statement in regard to the rarity of dry concrete is made advisedly, since only the most minute quantities of moisture are necessary in order to impart to concrete a considerable conductivity. On the other hand, the concrete has to be made very wet in order to impart to it a maximum of conductivity, and any reduction of the moisture content below the saturation point causes an increase in its resistance and a consequent decrease in the current which will flow through the concrete under a given potential gradient. The condition mentioned above, that the electric current must flow between electrodes in contact with the concrete, should be emphasized. The conduction being electrolytic, the reactions take place only at the electrodes, and in the absence of such electrodes no reactions occur within the concrete.

Sources of Stray Currents.—If there be electrodes embedded within the concrete, as in the case of reinforced concrete structures, the electrode effects may be expected provided the voltage is sufficient. The sources of potential differences in concrete structures may be classed under two heads, (1) those due to direct contact between the conductors of lighting or power circuits, and some part of the building and (2) those which have their origin in stray currents from railways or other grounded power lines. The former may happen in any building containing electric wires, through defective insulation. Ultimately, of course, any current that leaks off from the wire would pass out into the earth through the footings and foundations and through pipe systems entering the building. If the current be reversed, flowing to the building from outside, there would in time be some softening of the concrete in a thin layer under and around the steel structure terminating in the footing, but this would be under compression and not subjected to shear along the surface of contact between steel and concrete, so that failure here is extremely improbable. The only places where trouble is to be expected due to grounding of power wires directly on the concrete inside of a building is in the region close to the point of ground.

If, however, the power wire be grounded directly on a portion of the reinforcing material, the condition will be more serious, and the extent of the danger will be greater if there is a large quantity of the reinforcing material in metallic contact with the electric circuit. If this comprises a large part of the total reinforcement of the building, the condition might be serious irrespective of whether the positive or negative side of the line is grounded. If the ground is on the positive side the potential gradient near the reinforcement may become high enough to cause rapid corrosion and consequent destruction of the reinforcing material. If, on the other hand, the reinforcing material be negative, there would develop a softened condition of the concrete near the surface of the

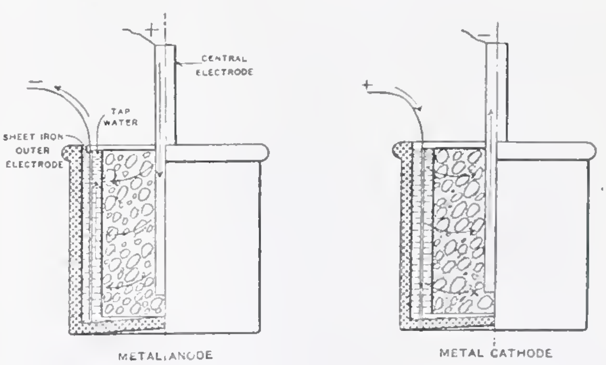


Fig. 2—Method of Making Connections to Specimens.

iron which would practically destroy the bond, and this would probably be the more serious condition of the two, since the latter would not manifest itself by producing local cracks in the concrete, and might not become known until a large portion of the building has become weakened. However, while such a condition as this might occur, and if neglected become very serious, it is nevertheless a trouble that can be readily guarded against, as will be pointed out below.

The other source of current that might possibly give rise to trouble under certain circumstances is the ground return of railways. The current may enter a building in two different ways. First, if the foundations under the two opposite sides of the building are at different potentials, there would be a tendency for a certain amount of current to flow up through the foundation on the one side, through the walls and floors of the building and out through the foundation on the other side. This condition may be said to exist to a very small extent in practically all concrete buildings, but it is not one that need cause any alarm.

The second way in which stray currents may enter a building is through water or gas pipes, lead cable sheaths, and similar structures. The low differences of potential that these usually bring about, would cause damage very slowly however, but where differences of 5 to 15 volts exist between the reinforcing material and the earth, it should be regarded as a dangerous condition, and "should be remedied at once."

The above statements in regard to the liability of damage under low or moderate differences of potential are intended to apply only to concrete which contains no appreciable quantities of salt. The data show that if a small quantity of sodium chloride (salt) or calcium chloride be added to the concrete the rate of deterioration proceeds many times faster, and under such circumstances much lower voltages should be regarded as dangerous.

Specific Cases of Trouble.—In the course of the investigations a considerable number of cases were examined in which damage to concrete structures has been attributed to electric currents. Some of these have been reinforced structures and some have been without reinforcement. Among these not any nonreinforced structures were found in which the conditions indicated that electric currents could in any way be responsible for the damage. Among the reinforced structures there are some in which electrolysis has been at least a contributing cause of the damage. The investigators, however, have seen no case in which serious damage has occurred in which there was not also present a considerable quantity of salt in the concrete, either from having been put there during construction or from contact with salt water in service.

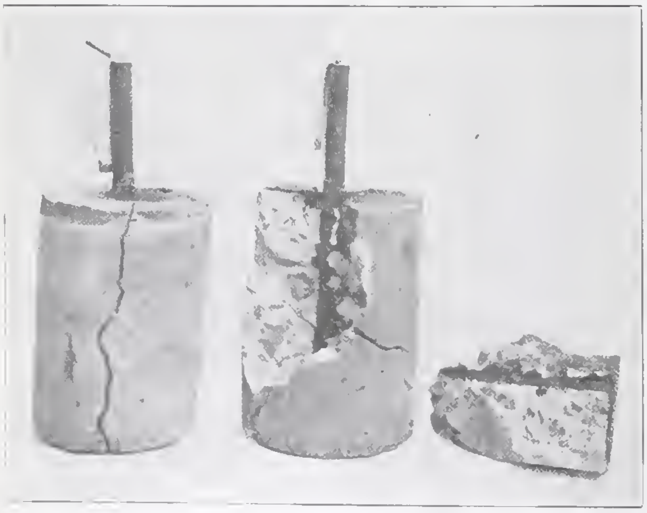


Fig. 3—High Voltage Anode Specimens.

Protective Measures.—Recommended protective measures mentioned are briefly, (1) the exclusion of salt (an addition of even a fraction of 1 per cent of chlorine is sufficient to increase the rate of damage a hundredfold), (2) waterproofing below grade, (3) proper selection of materials for the foundations (of secondary importance however), (4) inclosure of electric wiring in continuous metal conduit, (5) introduction of insulating joints into pipes and lead cable sheaths before they enter the building, (6) improvement in the negative return of railways, (7) the abolishment of the practice of grounding metallic conduits in contact with concrete. Waterproofing compounds, and the making of reinforcing material negative by means of a low-voltage generator are of little value and are not recommended.

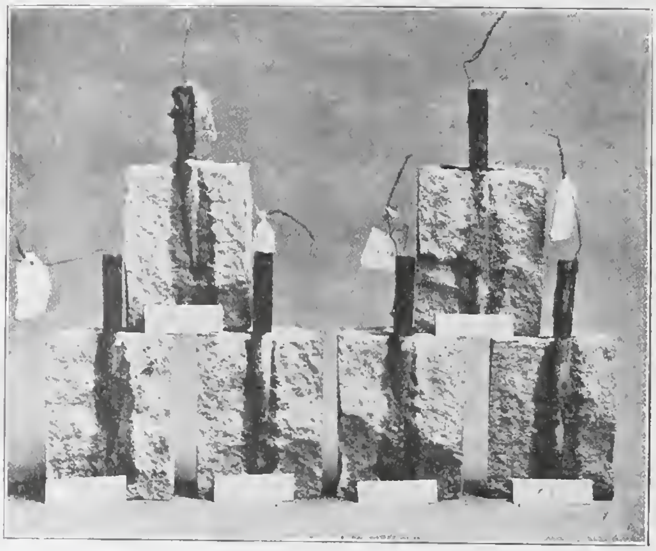


Fig. 4—Cathode Specimens Showing Disintegrated Mortar About Electrode.

Copper-clad steel or aluminum for reinforcing material is impracticable, since the copper coating is readily destroyed and aluminum is attacked by alkali in the concrete.

Position of A. A. E. on Trade Unionism in the Profession

The executive committee of the American Association of Engineers has issued a statement defining the attitude of the Association as regards trade unionism in the profession. The statement, in part, follows:

The engineer is the medium through which both capital and labor are used in production and industrial development. The aim of the profession is to advance civilization and render the highest service to society. Except when their acts further this aim, it is an advocate of neither capital nor labor.

Production should be increased—not limited. The profession cannot support strikes or lockouts or any other methods that may benefit any class at the expense of the nation as a whole. They are unsound and must inevitably lead to economic disaster. The law for supply and demand for men or material must ultimately prevail. Attempts may be made to limit the supply of either, but looking toward the upbuilding of civilization we believe rather in increasing the demand through the promotion of legitimate enterprises.

Rewards should be according to ability, initiative and constructive effort. Men are not equal in these respects. Each man should be encouraged to do his utmost and be given compensation according to ability and will to increase production and to achieve large results.

The engineer, as an educated professional man, believes in basing his claims for proper and just reward for his services upon the justice of the fact presented, upon enlightenment of public opinion, upon loyalty between employer and employe, and upon the underlying fundamental desire of the great majority to do what is fair and right when the merits of the case in question are clearly presented and demonstrated. We believe in organized representation for the correction of wrong, the advancement of the profession and service to the public, but are opposed to methods inconsistent with the dignity of the profession and which would lessen public confidence.

The American Association of Engineers, through its Board of Directors and officers who unanimously signed this statement, recognizing the many fundamental differences between the principles and objectives of the trade union and of an organization of professional men, expresses the opinion that an engineer cannot subscribe to the tenets of both.

The Economics of Steel Arch Bridges

By F. H. Frankland, M. Am. Soc. C. E. Consulting Engineer.

An abstract of a paper by Dr. J. A. L. Waddell, in "Proceedings," American Society of Civil Engineers, Vol. XLIV, No. 3, March, 1918.

For many years American bridge engineers have felt the need of reliable information concerning certain fundamental economic functions of steel arch bridges and especially concerning the relative costs of such structures in comparison with corresponding truss bridges. The want of such information has resulted in the failure of American engineers to develop the steel arch and to use it in places where it would be both more economic and more esthetic than the simple truss bridge. Wherever the governing conditions of crossing are suitable for an arch structure, that type of bridge is to be preferred; for, the arch, in all places where its use is really justified, is less expensive than the truss bridge.

For 20 years or more, Dr. J. A. L. Waddell, the wellknown bridge specialist, had been urging the engineering profession to make certain investigations which would settle every uncertainty concerning the economics of designing steel arch bridges, as well as the relative costs of these structures in comparison with the corresponding truss bridges. As long ago as 1898, when he wrote his widely-read little treatise, "De Pontibus," he appealed to the engineering profession as follows:

> In concluding this chapter, the author desires to call attention to the fact that there is still a great deal to be learned about the designing of arches; and to suggest that some professor of civil engineering, who is well posted on bridge designing and who has time to spare, could spend several months to the great advantage of the engineering profession in determining the proper relations of span lengths, rise, arch depth, width between exterior arches, etc., for the various styles of arch, and in ascertaining the relative economics of the latter.

During the 18 years which elapsed between the issuing of "De Pontibus" and its successor, "Bridge Engineering," Dr. Waddell made repeated attempts to find some bridge engineer who would be willing to undertake the task which he had suggested—but without avail; and in the last mentioned treatise (page 637) he made another forcible appeal to the profession to undertake the requisite investigations—with the same result as before. Finally, in 1917, despairing of ever being able to induce anyone to assume the obligation, he himself shouldered the burden by making, with the aid of one of his assistants, all the calculations needed to determine every desired point, and from the results thereof prepared a paper on "The Economics of Steel Arch Bridges," which he presented to the American Society of Civil Engineers.

Synopsis of Dr. Waddell's Paper.—As soon as he learned of its acceptance by the publication committee, he sent a circular letter to all the bridge engineers in America whose address he could obtain, as well as to a number of prominent engineers abroad, inviting them to discuss the paper, and enclosing the following synopsis:

> Up to the present time, nothing at all certain has been known concerning the economics of steel arch-bridges, the weights of metal required to build them, or how they compare in cost with the corresponding steel truss-bridges.
>
> The objects of this paper and its anticipated discussions are to settle finally every important economic question that can arise in the designing of steel arches: to give formulas and diagrams for determining, with a fair amount of accuracy, the weights of metal in both arch-bridges as a whole and the arches themselves; and to indicate the relations between the weights and costs of arch-bridges in comparison with those of the corresponding truss-bridges.
>
> There are eight economic problems set for solution; and all of them have been solved—the first two by employing certain formulas given in the author's new book on "Bridge Engineering," and the other six by means of a large number of special arch-designs and the resulting estimates of weights of metal. Incidentally, during the investigation there have arisen and been solved a few minor questions which may properly be termed side-issues. The computations have been made for both railway and highway arch-bridges; and the weights of metal are plotted for both carbon-steel and nickel-steel structures. Several diagrams are given to show the percentage effects of weight-increase due to departure from economic conditions.
>
> The need for the special knowledge concerning arch-bridges presented in this paper has been recognized during the last three decades by American structural-steel-engineers; but the authors of books on bridges (this author included) have hitherto avoided the issue because of the immense amount of work involved in the solution of the various problems. The author has tried of late years on several occasions to persuade some of his brother engineers to undertake the task; but not meeting with any success, he finally decided to do the work himself. The results of his efforts are herewith presented to the members of the society with a most earnest request for a thorough discussion, particularly by those who specialize in bridge work.
>
> The principal economic problems concerning the design of steel arch-bridges which have been solved for this paper are the following:
>
> First. The economic ratio of rise to span-length.
>
> Second The economic depths for the ribs.
>
> Third. The economic location for the crown-hinge in three-hinged, spandrel-braced arches.
>
> Fourth. The ratios of weights of metal required for the hingeless, the two-hinged, and the three-hinged types.
>
> Fifth. The ratios of weight of metal required for the solid-rib, the braced-rib, and the spandrel-braced types.
>
> Sixth. The economics involved by making arches three-hinged for the dead load and two-hinged for the live load.
>
> Seventh. The economy of the cantilever-arch with suspended end-spans, as compared with an ordinary arch and two flanking simple-truss-spans.
>
> Eighth. The ratios of weights of metal required for certain portions of arch bridges as compared with the corresponding portions of simple-truss bridges of the same span and same live-load-carrying-capacity.

In answer to this request, a number of engineers, both at home and abroad, discussed the paper; and their discussions have been printed in several copies of the Society's "Proceedings." These discussions were thoroughly analyzed by Dr. Waddell, and replied to in his closure, which was published in the "Proceedings."

The discussions did not result in the modification of any of the author's findings with one exception—and in that one not seriously. It was pointed out that the first two problems were solved by the use of certain semi-rational, semi-empirical formulae for weights of metal in arches established in Chapter XXVI of "Bridge Engineering," but that the other six were settled by means of actual computations of weights of metal determined from specially prepared diagrams of stresses and sectional areas of main members.

Mr. C. E. Fowler in his discussion, included a tabulation of the salient features and dimensions of 100 of the world's largest arch bridges, showing that the author's finding for economic ratios of rise to span-length agreed fairly well with the averages computed from existing structures, but that his deduced economic ratio of depth of arch ring to span-length did not; whereupon the author agreed to settle this question beyond a doubt by submitting it to the incontrovertible test of making actual designs and estimates of weights for arches of 500 ft. span, of economic ratio of rise to span-length, and having regularly varying depths of arch ribs, so as to determine the depth producing the least weight of metal. This was done; and the results of the special calculations were given in the author's resumé, which showed that, for short-span railroad arch-bridges, his previous finding was correct; but that, for the corresponding long-span structures, it was somewhat too great—also that his conclusion to the effect that the economic depth for arch ribs is the same for both railway and highway bridges is incorrect. The reason for the variation in the two findings is that the weight formulae upon which the first investigation was made, were of too empirical a nature to warrant their use for an exact determination of economic depth of arch rib. From the original paper, the discussions, and the resumé, the following answers to the set questions have been arrived at.

Economic Rates of Rise to Span-Length.—For three hinged arches with the grade line approximately tangent to the top chord of the arch at the crown, the average economic ratios of rise to span-length are as follows:

Solid-rib structures	0.2
Braced-rib structures	0.225
Spandrel-braced structures (with hinge above)	0.25

These values may be either increased or decreased by 0.025 without making any material difference in the economics.

For three-hinged, half-through arch-bridges, the average economic ratios of rise to span-length are as follows:

Solid-rib structures	0.225
Braced-rib structures	0.3

For three-hinged, high-deck arch-bridges, they are as follows:

Solid-rib structures	0.25 to 0.28
Braced-rib structures	0.33 to 0.38

For two-hinged arches and combined two-hinged and three-hinged arches, the economic ratios of rise to span will be practically the same as for three-hinged structures.

For the hingeless arch, a somewhat greater ratio of rise to span than that for the three-hinged arch is economical. The single test of this made for the 500-ft. span indicates that the best ratio is about 0.28 with low-grade deck, 0.33 for half-through arches, and 0.38 with high-grade deck.

Economic Depths for Ribs.—In respect to solid-rib arches, the question of economic rib-depth does not arise; for the depth should always be made as great as a proper consideration of the section for resisting compression will permit, and with due regard to shipping restrictions concerning limiting sizes of single pieces. For braced-rib, three-hinged arches in steam-railroad bridges, the economic rib-depth varies from 7.8 per cent of the span-length for 100-ft. spans to 5.3 per cent thereof for 1000-ft. spans; and for highway bridges, the corresponding variation is from 5.8 per cent to 4.2 per cent.

Economic Location of Crown-Hinge.—It was found for all cases that the most economic location for the Crown-hinge in a spandrel-braced arch is in the top chord. In braced rib and solid-rib arches, however, the hinge should always be placed at mid-depth, so as to distribute properly the thrust over the two chords.

Ratios of Weight of Metal.—Comparing the economics of solid-rib, braced-rib, and spandrel-braced arches, it was found that the first mentioned is always considered heavier than either of the others; and, under normal conditions of the metal market, it is also more expensive. The spandrel-braced arch requires for long spans a little more metal than the braced-rib arch; but, in case of cantilevering this would generally be offset by the extra quantity of erection metal needed for the braced-rib structure. In short spans, the spandrel-braced arch is a trifle the lighter.

Comparing three-hinged, two-hinged, and hingeless arches, it was found that the three-hinged is a little heavier than the two-hinged, but nearly always lighter than the hingeless. The variations in weight among the three types, however, are never great.

The combination of three hinges for dead load and two hinges for live load produces very little saving over the three-hinged type; but it adds materially to the rigidity. In the writer's opinion, the combined type is preferable to any of the others.

Economy of Cantilever Arch.—When an arch is flanked by other spans than arches, there is generally quite a little economy involved by cantilevering the ends of the arch and shortening the lengths of the simple spans. The best proportions for lengths of cantilever arm and suspended span to total length of flanking span are, respectively, 0.4 and 0.6.

Ratios of Metal Weights in Arches and Simple Spans.—The ratios of weights of arches to the weights of the corresponding simple spans for both railway and highway bridges have been determined and plotted. As was anticipated, the arch usually effects a greater relative economy in highway structures than in railway structures of the same span-length; and, the longer the span the greater always is the proportionate saving of metal.

In concluding his paper, the author quotes as follows from one of his previous publications:

> In dealing with the comparative economics of arches and simple trusses, it must not be forgotten that there are other factors than mere weight of metal involved; for the pound price of the manufactured material is generally somewhat greater for the former, and sometimes the cost of erection also is larger. Again, the comparison of the costs of arch superstructures and truss superstructures alone is not of much importance; for an economic investigation, to be of any value, must include both substructure and superstructure; and the costs of the former are likely to be very different in arch designs and simple-truss designs for any crossing.

Some of the "side issues" referred to by the author in his "Synopsis" are the following:

Equations for Finding Weight of Metal for Arch Ribs.—The percentage to apply to weights of metal in simple-truss spans, in order to find the weights for arch ribs and the superimposed columns with their bracing to carry the same live loads, are given by the following equations:

For steam-railway structures—

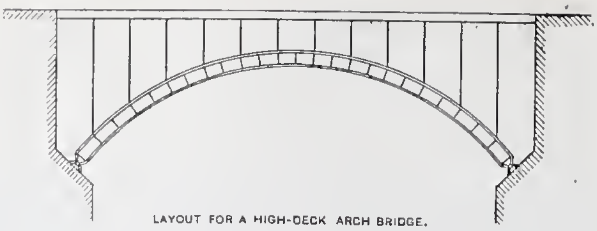
$$P = 106 - 0.08\,S$$

For electric-railway structures—

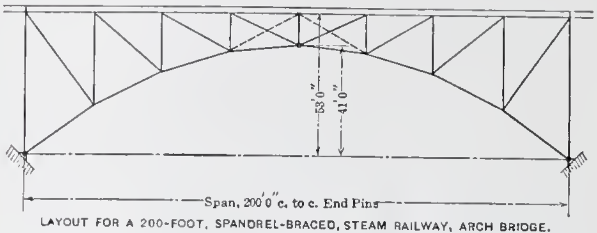
$$P = 93 - 0.07\,S$$

For highway structures—

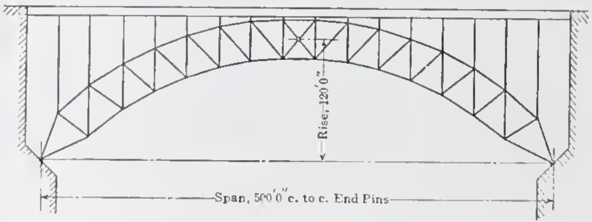
$$P = 80 - 0.056\,S$$



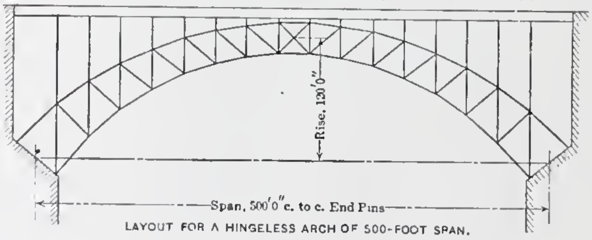
LAYOUT FOR A HIGH-DECK ARCH BRIDGE.



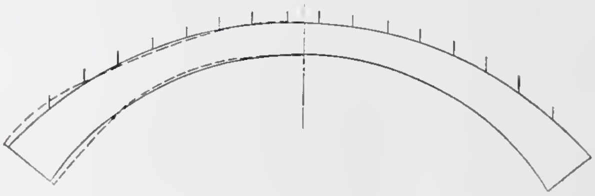
LAYOUT FOR A 200-FOOT, SPANDREL-BRACED, STEAM RAILWAY, ARCH BRIDGE.
(Dotted lines represent reversed position of the diagonals at the crown when the hinge is located in the top chord.)



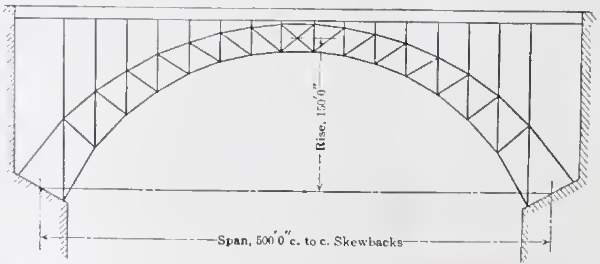
LAYOUT FOR THREE-HINGED AND TWO-HINGED ARCHES OF 500-FOOT SPAN.
(In the three-hinged arch the chords in the middle panel are false members)



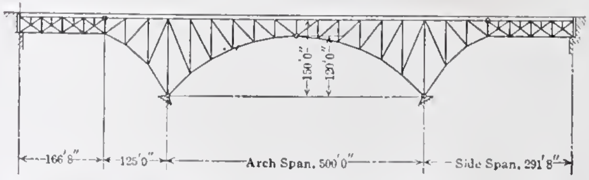
LAYOUT FOR A HINGELESS ARCH OF 500-FOOT SPAN.



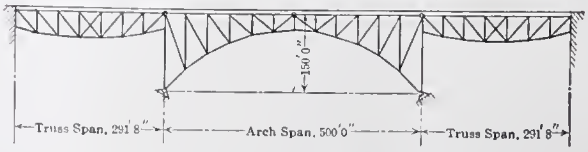
LAYOUT FOR A HINGELESS ARCH OF 500 FEET SPAN, SHOWING MODIFICATION FOR DEPTHS PROPORTIONATE TO ADJUSTED BENDING MOMENTS.
(Solid lines represent original outline as adopted for design, and dotted lines represent modified ideal outline.)



LAYOUT FOR A HINGELESS ARCH WITH A RATIO OF RISE TO SPAN OF 0.3



LAYOUT FOR A CANTILEVER ARCH BRIDGE.



LAYOUT FOR AN ARCH BRIDGE, WITH FLANKING SIMPLE-TRUSS SPANS.

Typical Layouts Used in Investigation.

In these equations, S is the span-length in feet, and P is the percentage to apply to the weight of metal in the trusses of any simple-truss bridge, in order to ascertain the weight of metal in the corresponding arches and the superimposed columns with their bracing. It must not be forgotten that the superior limit of S in these equations is about 1000-ft., which is as far as the recorded weights of simple-truss spans are carried, and that the inferior limit is 100-ft.

It is evident from the computations and the resultant diagrams that the arch is more economical for highway bridges and for combined highway and electric-railway bridges than for steam-railway structures. This is because of the smaller ratio of live load plus impact to total load in the former. The larger the dead load of the flooring and floor-system, the more advantageous is it for the arch structure in comparison with the truss bridge.

Formulae for Weights of Metal in Arches.—Based on the numerous weight computations made specially for the preparation of this paper, the following formulae for weights of metal in the arches alone, per lineal foot of span, in arch bridges of the several types, have been established:

For three-hinged arches:

$$W_a = (0.0002282\,D + 0.000426\,L)l \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

For two-hinged arches:

$$W_a = (0.000248\,D + 0.000416\,L)l \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

For combined two-hinged and three-hinged arches:

$$W_a = (0.000282\,D + 0.000416\,L)l \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

For hingeless arches:

$$W_a = (0.000272\,D + 0.000460\,L)l \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

These four formulae are based on the author's published designing specifications, which treat reversing stresses by adding one-half of the smaller stress to the larger stress and proportioning for the sum; but if the effect of reversion is entirely ignored, as some engineers deem proper, these formulae will reduce to the following:

For three-hinged arches:

$$W^1_a = (0.000292\,D + 0.000396\,L)l \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

For two-hinged arches:

$$W^1_a = (0.000258\,D + 0.000380\,L)l \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

For combined two-hinged and three-hinged arches:

$$W^1_a = (0.000292\,D + 0.000380\,L)l \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

For hingeless arches:

$$W^1_a = (0.000270\,D + 0.000398\,L)l \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

In Equations (2) to (9) inclusive, W_a, or W^1_a, is the weight of metal, in pounds per linear foot of span, in the arches of the structure; D is the dead load, in pounds per linear foot of span; L is the live load plus impact, in pounds per linear foot, used in making the calculations; and l is the span-length, in feet. These eight equations will give fairly accurate results (slightly on the side of safety) for ordinary conditions which do not vary greatly from the theoretically economic ones.

In computing the value of L for insertion in Equations (2) to (9) inclusive, the equivalent uniform live load and the impact should be determined for the half-span-length, as herein previously indicated.

Deductions from the Formulae.—From the formulae given above for weights of arch ribs, some interesting deductions may be drawn. For instance in the equation,

$$W_a = (0.000282\,D + 0.000426\,L)l \quad \text{(Eq. 2)}$$

the dead load, D, is composed of the rib weight, W_a, plus the weight of floor, columns, lateral system, etc., all of which may be grouped under the symbol W^1, making the equation,

$$W_a = (0.000282\,W_a + 0.000282\,W^1 + 0.000426\,L)l.$$

Solving this gives:

$$W_a = \frac{(0.000282\,W^1 + 0.000426\,L)l}{1 - 0.000282\,l}$$

In order that W_a may be infinitely great, the divisor of the second term must be equal to zero, or

$$l = \frac{1}{0.000282} = 3{,}540 \text{ ft.}$$

This is the theoretical limiting span length for three-hinged arches of carbon steel, or the span at which such an arch could carry nothing but its own weight without being overstressed. It will be noted that this limiting length is the reciprocal of the dead-load coefficient in Equation (2), and that a vertical line on the diagram of arch rib weights per linear foot of span, drawn through the abscissa point which represents this value of l, will be asymptotic to the weight curve.

Economic Limit of Arch Spans.—From the curves in the diagrams it is possible to determine the economic or practicable limit of arch spans, by assuming, as the author did years ago in his economic investigations for cantilevers, that the said limit is reached when it takes 4½ lb. of metal to carry 1 lb. of live load. On that basis, and assuming that the equivalent uniform live load per lineal foot, the limiting weight of metal per foot for carbon-steel, double-track, steam-railway bridges of Class 60 would be 4.5 × 12,000 = 54,000 lbs., the span-length for which weight is nearly 2,100 ft. Generally speaking, it may be stated that, for steam-railway arch-bridges of carbon-steel, the limiting length of span is about 2,000 ft., or the same as the limiting length of main opening in cantilever bridges built of the same material. Judging by analogy, the corresponding practicable limiting length of nickel-steel arch-spans is about 2,600 ft.

The Substructure.—It is impracticable to take the substructure into account when making general economic investigations for arch-bridges, because no two cases thereof are alike In case of a succession of long spans in which there is a choice of rise, a tentative layout should be made using the anticipated economic ratio of rise to span-length when both substructure and superstructure costs are considered, then the costs of piers and spans should be computed, the uneconomic effect of departing from the established economic ratio of rise to span-length given in several of the diagrams being employed to calculate the weights of metal from those shown in certain other diagrams.

Next, this work should be repeated for a slightly greater ratio of rise to span-length, and then for a slightly smaller ratio thereof. These three sets of computations would probably determine the best ratio to adopt; but, if not, still another set of calculations would be necessary. The computation work involved in this investigation is not as great as a perusal of the preceding directions might lead one to think, especially after the computer has become accustomed to utilizing the diagrams of the paper and to estimating quickly the approximate quantities of masonry in arch-piers.

In the cantilever arch the reduction of the horizontal thrusts at the tops of the piers, as compared with simple or non-cantilevered arches, effects a decided saving in the cost of the piers; and the greater the proportionate lengths of the flanking spans to the arch span, the larger the economy in pier material.

Some engineers who adhere to old-fashioned notions contend that masonry or concrete arch-bridges are applicable to bed-rock foundations only, and that the piers and abutments therefor should never rest on piles. While it is true that bed-rock is the ideal foundation for such structures, pile foundations can be made entirely satisfactory, provided that the masonry of the bases is carried well down into firm material that is capable of resisting properly the horizontal thrust. It is not legitimate to count upon the horizontal resistance of the piles; and it would be bad practice to rest the piers and abutments of an arch-bridge on piles the tops of which below the pier bases act like stilts because of passing through soft material before reaching a hard bearing.

As stated by the writer in his discussion, "in respect to arch designing, the proper determination of the true economics calls for more judgment on the part of the designing engineer than with any other type of bridge."

The paper and the resumé contain some 30 diagrams which cannot well be reproduced in this article; hence the reader who desires to utilize the full results of this most thorough, arduous, and valuable investigation, is referred to the paper itself, which, with all the discussions and the resumé is soon to be published in the "Transactions" of the American Society of Civil Engineers. Some of the typical layouts used in the investigation are, however, reproduced herewith.

Before concluding it might be well to quote the following caution given by the author to those intending to utilize the information furnished in his paper:

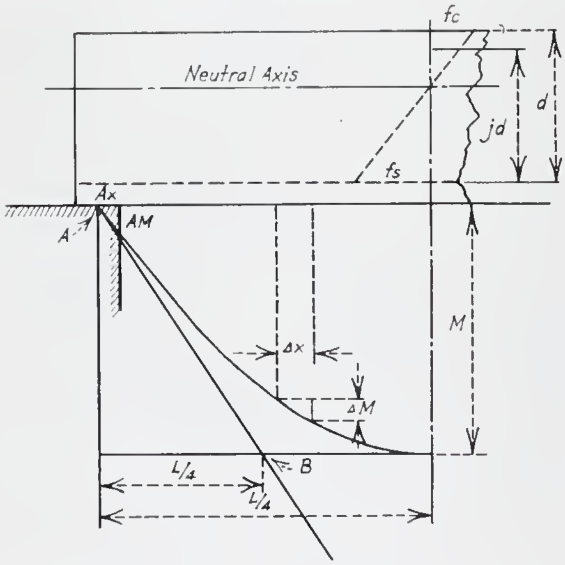
> The various formulae and diagrams in this paper are to be considered as merely approximate; and though they are sufficiently accurate for preliminary estimates and for obtaining trial dead loads, they should not be used by contractors in tendering on work. The reason for this uncertainty is that the varying physical conditions at different crossings affect the arch layouts to such an extent as materially to influence the weight of metal required As the formulae were based on economic functions, the weights given by their use might very properly be considered as the minima possible; and any uneconomic conditions which may exist will involve an increase thereof, the amount being a matter to be determined by the computer's judgment.

Criticism of the Ordinary Methods of Designing Reinforced Concrete Beams.

By JAMES W. PEARL.

If an uniform load per lineal foot is carried by a reinforced concrete beam of uniform cross-section, simply supported on bearings at each end, the curve of moments produced will be represented by a parabola.

The vertical ordinate to the curve at any point represents the total stress in the reinforcing bars at that vertical section, and the difference in length of any two ordinates is a measure of the variation in stress in the reinforcing bars between corresponding sections that must be transmitted to the bars by the adhesion between the concrete and steel.



Let the figures represent one half of such a beam and its moment curve.

Let L = the length of span in feet.
Let W = the load per lineal foot.
Let M = the moment in foot-pounds at the center of span.
Let V = the shear at any section.
Let A = the area of reinforcing steel.
Let p = the ratio of steel to concrete.
Let b = the width of beam in inches.
Let f_s = the unit tensile stress in steel.
Let u = the unit adhesion between concrete and steel.
Let s = the diameter of round or square bars in inches.
Let o = the periphery of reinforcing bars.

When the two ordinates are consecutive, the horizontal distance between them is expressed by ΔX, the variation of moment by ΔM and $\Delta M/\Delta X$ is the tangent of the angle the moment curve makes with the horizontal at that point. We also know from the theory of stresses in beams that $\Delta M = V\Delta X$, and by dividing by jd, $\Delta M/jd = V\Delta X/jd$. But $\Delta M/jd$ is the adhesion required between the concrete and steel in any length ΔX and V/jd is the shear per unit of depth; taking ΔX as unity we can then state that the adhesion required per unit of length equals the shear per unit of depth.

We can now write the relation between the shear and adhesion at the support as follows: $V/jd = (WL/2jd = \Sigma ou$, and by substituting for WL in terms of M, $WL = 8M/L$, $\Sigma ou = 4M/Ljd$ or $\Sigma ou\, L/4 = M/jd$; interpreted, **the adhesion required at the supports multiplied by one quarter of the length of span must equal the stress in the bars at the center of the span.**

This may be demonstrated in another manner by drawing tangents to the moment curve at the center and at the points of support; they will intersect at B at a distance of L/4 from the center and by similar triangles $\Delta X:\Delta M::L/4:M$, or $\Delta M = 4M\Delta X/L \therefore \Delta M/jd = 4M/jd\,L = WL/2jd = \Sigma ou$.

The area of round and square bars in terms of their periphery and diameter is $OS/4$ and the value of M in inch pounds is $12WL^2 \div 8$. Substituting, we have:

$$\frac{12WL^2}{8jd} = Af_s = pbdf_s = \frac{\Sigma osf_s}{4} = \frac{WLsf_s}{8ujd} \quad \ldots\ldots\ldots (1)$$

$$\text{So, } 12L = s\frac{f_s}{u}$$

This establishes a relation between the length of span and diameter of reinforcing bars that should be observed when the unit tensile and adhesion stresses are determined.

A comparison of the unit stresses allowed in various specifications will reveal a ratio between u and fs varying from 150 to 300 and only rarely a restriction as to the diameter of bars that may be used.

Assuming a ratio of 200 ($f_s = 16{,}000$, $u = 80$) and substituting in the above equation, $13L = 200s$, ... (2) or, **the diameter of bars should not be greater than one-two-hundredth of the span.**

Other ratios of f_s to u may be acceptable to a designer, but for each ratio there will be a limiting size of bar for every length of span that should not be exceeded.

Variations in the intensity of internal stresses in concrete surrounding a reinforcing bar are unavoidable, and as they are destructive in proportion to their magnitude some limit is desirable.

Between the upper side of a single course of reinforcing bars and the neutral axis the horizontal shear is equal to Σou, (this is not always true but will be used because it is commonly accepted by writers on this subject) and at the lower side of the bars it is zero. It is impossible to secure an uniform variation in stress from the upper to the lower side of bars, but the rate of variation will be diminished as the spacing of bars is increased, which is an argument for bars of as large diameter as can be conveniently used.

A compromise is necessary, and for the purpose of illustration we will take $\Sigma o = b$, which will make the units of adhesion and shear equal. This relation is selected because the accepted principles of internal stress require that in an homogeneous material the intensity of shearing stresses upon two planes at right angles to each other must be equal. With $\Sigma o = b$, the spacing of round bars will be nearly 3s and of square bars exactly 4s.

From equation (1) we have $\Sigma osf_s = 4pbdf_s$ when W equals the load per square foot and $b = 12$, this reduces to $s = 4pd$. This, taken in connection with the limit on the diameter of bar that may be used for a given length of span places a limit on the percentage of steel or the depth of beam that it is rational to use with a single course of reinforcing bars, and it follows that there is a limit to the load per square foot that can be supported by a reinforced concrete beam without ignoring all of theories presented by writers on this subject

From equation (1) we also have $12Lu = Sf_s$ and $WL = 2.\ \Sigma oujd \therefore W = \frac{24\,\Sigma ou^2jd}{Sf_s}$

Substituting the value of s, $W = \frac{6\,\Sigma\, ou^2j}{pf_s}$ and as $\Sigma o = 12$,

$$W = \frac{72\,u^2j}{pf_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

This is the expression for the maximum uniform load per square foot that can be provided for in a simple reinforced concrete beam or slab according to the common theories used in designing.

In equation (3), j is nearly constant and u and fs are generally selected by the designers so **the load that may be provided for will generally vary inversely as the percentage of steel used for reinforcing.**

The shearing strength of good concrete fairly cured will generally average from 50 per cent to 60 per cent of its strength in compression, so the ordinary requirements in designing that limits the shearing stresses to about 10 per cent of the unit compression stress should be recognized as an empirical or "thumb rule" to relieve the authors and their followers of brain fag.

The rule is a vicious one because it diverts attention from the adhesion unit stresses that are commonly overlooked at points of maximum shear and results in a design with inadequate steel surface in one place or unnecessary concrete in another.

The rules commonly applied in designing what purports to be "shear reinforcement" are based on the vertical shear at the section of beam under consideration; some writers apologize for the rules and acknowledge that the steel is introduced to resist rupture by diagonal tension. But diagonal tension is a function of both the shear and tensile stress in the concrete, with the tensile stress predominating and maximum at the center of span, while the shear is maximum at the ends, when the beam is simply supported, so any rule based on the shear only is erroneous.

On cantilever and continuous beams the shear is maximum and moment nearly maximum at the edge of supports; this combination of stresses make it a section in which the designer should compute the diagonal tensile stresses and provide suitable steel to resist them, he should also observe that the total safe shear does not exceed $\Sigma o u j d$, in which $\Sigma o u$ applies to the upper or negative reinforcing bars only. Many of the unsightly cracks in reinforced concrete construction, in the region of supports may be explained by checking with the above rules.

The diameter of bars used, except in long spans, should generally be smaller than many designers select. With the unit stresses heretofore mentioned a rule for diameter of bars in preliminary designing is as follows:

In straight cantilever beams	0.010 arm.
In straight simple beams	0.005 span.
In straight continuous beams, at center. .	0.003 "
In straight continuous beams, at support.	0.005 "

When a part of the bars are bent or curved upward toward the neutral axis to resist diagonal tensile stresses, the diameter of all the bars should be reduced by the ratio that the bent bars bear to the total number.

Is Man a Rational Animal?

(An editorial in Scientific American.)

A certain group of economists, of whom Jevons may be taken as the representative, have developed a system based on the fundamental principle that man seeks so to arrange his affairs, his productive activities and his sales and purchases, as to derive maximum amount of pleasure therefrom. Another group, who, perhaps, might be typified by the name of Veblen, insists that this principle is fallacious, that man is not the rational creature assumed by Jevons and his followers, that so far from calculating at every step the profit and loss, the pleasure and pain which will accrue to him from the various courses of action open to him, he is very largely a creature of instinct, and that a very large proportion of his actions are based, not at all on a careful weighing of consequences, but on wholly nonrational instinct. So, Veblen points out, some men work for the mere love of their work, and if their circumstances permit, they will count neither cost nor profit; while others go on amassing wealth for the love of pomp and show, and not at all from calculating motives which should strike a nice balance of credit and debit in pleasure and pain.

There is probably something to be said for each side in this dispute. The Jevons school retorts that it has by no means overlooked the instincts to which Veblen attaches so much importance. These very instincts determine the pleasure which a man derives from a given course of action, from the consumption of a given set of economic commodities.

On the other hand, it is probably true that unreasoning instinct plays a much greater part in human affairs than is commonly supposed. Psychologists tell us that we have an inveterate habit of deceiving ourselves as to our true motives. The slacker, who is afraid for his skin, pretends high philanthropic motives and calls himself a "conscientious objector"; and we, if we are honest with ourselves, will often find ourselves similarly hiding our true motives under a paint of some more attractive hue. And so, the reasons professed for our actions are often not the true ones; on closer inspection it is commonly found that where we pretend to be guided by reason, we are in truth following the more or less direct promptings of a fundamental instinct.

If our instincts were always opportune, there would perhaps be no disadvantage in non-rational, instinctive action. But man, with all his boasted superiority, is still very far from that state in which either his instincts or his reason are perfect guides. Very aptly Professor Stephen Leacock has drawn attention to the strange spectacle which a human community would present to some disinterested spectator, viewing it, say from another planet.

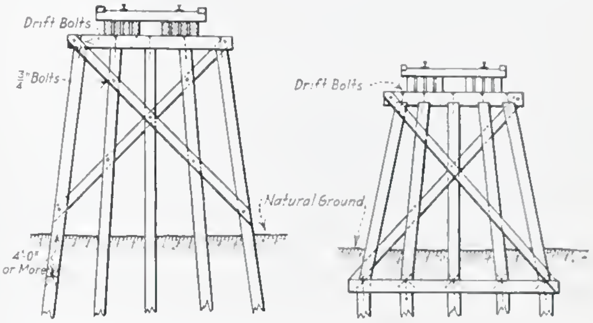
77½ Per Cent Capacity of Fabricating Shops Contracted for in October.—The records of the Bridge Builders' & Structural Society as collected by its secretary, show that during the month of October, 1919, 77½ per cent of the entire capacity of the bridge and structural shops of the country was contracted for.

Methods of Renewing Timber Bridges

An interesting resume of the present practice of railways in repairing timber bridges was given in the committee report submitted last month at the 29th annual convention of the American Railway Bridge and Building Association. The following is abstracted from the report:

Gang and Material Distribution in Repairing Timber Bridges.—In general, gangs for timber bridge work consist of a foreman, an assistant foreman and 6 or 8 men, as follows: Two first-class carpenters, two assistant carpenters and two to four laborers. Variations from the above are made as the work demands or in accordance with the kind of men available.

The distribution of material depends on the quantity to be handled and traffic conditions. Where material is ordered from the mill, cars may be consigned to the station nearest the bridge site for unloading or redistribution by one of the methods mentioned below. When shipped from the storehouse, the use of company service cars may be found convenient. These can be held under load and shipped from point to point as the work progresses. For unloading use may be made of a special work train or, where the quantity of material does not justify this expense, recourse may be had to a local freight train. When two or more cars are to be unloaded it may sometimes be found economical to distribute the unloading by local freight train over several days. Small quantities are handled by motor trailer or push car.



Method of Replacing Portion of Pile Bent by Frame Bent.

There does not seem to be uniformity of practice in the use of second-hand material in any given part of the bridge. It would appear to be the best policy to use second-hand material only for blocking and helpers on important lines, but it might be used somewhat more generally on light traffic lines in bridges, the life of which will not be greater than the life of the material.

Replacing Portion of Pile Bent by Frame Bent.—Where one-third or less of the piles in a bent are in bad shape satisfactory repairs can usually be made by cutting off in solid material at or below the ground line, and setting in a post on this foundation. Such a post will have a better appearance if it is of the same shape as adjacent piles. It should be spliced to the foundation pile with four 3-in. scabs bolted through, drifted through the cap at the top and well bolted to the bracing. It should have an identifying mark as a helper. Posts are sometimes put in on blocking between piles. A weak pile may thus be relieved of some of its load and at the same time the benefit of its stiffness be retained. A repair of this kind is an obstruction, if placed in a stream, and is unsightly in any situation. In cases of settlement, or where piles are decayed far below the ground line, it may be necessary to drive a new pile alongside the old one and spring it under the cap. When entire bents are to be removed, in most cases the pile may be cut off at sound timber below the ground line and a frame bent erected on this solid foundation. The bent should be framed without a cap, set up and made ready to slip in as soon as the piles are cut off. When conditions require it an entire new bent may be driven alongside the old bent, the new piles sawed off, the old piles cut out and the new bent pulled into place. Some roads restrict the height at which frame bents shall be used in this manner to 10 ft. In renewing caps it is first necessary to pull the stringer bolts to clear the cap. Then jack up the deck 1 or 2 in. (jacks may be supported on the ground or on sash timbers bolted to the piles for the purpose), raise the old cap to give room to cut off the drift bolts with a hack saw. When this is done, roll off the cap. The new cap having previously been framed and a hand line attached about its center, let it down over the side of the deck and swing it into place. Drift it to the piles, lower the deck and redrive the stringer drift bolts. When a scaffold is necessary for this work it may be hung from the ties with staging hooks carried regularly in the outfit for this purpose. An old cap may also be removed readily by cutting it into three or four pieces and splitting it out. This gives easy access to the drift bolts in the tops of the piles.

Renewing Stringers, Ties, Etc.—The renewal of an outside stringer is quite simple, as it is only necessary to withdraw the bolts, jack up the rail and ties about 2 in., turn down the stringer to be removed, shove it out on the caps, drop the new stringer previously framed on the caps and raise it up and bolt it. To renew the middle stringer in a chord the method is similar, but with broken joints it is necessary to remove the bolts extending over four panels. After raising the track, the two outside stringers are laid down, the weak center stringer removed, the new one placed and the balance of the chord reassembled. When it is necessary to renew an inside stringer it may be done in single panel lengths from the inside as described above, the new stringer being handled with lines through the deck. In renewing an inside stringer extending over two panels, it is necessary to take up the guard rail and shift the ties, either along the track or to one side. It is then possible to drop the new stringer vertically into place. This method may also be followed with center stringers. Some prefer to raise the track a little more than the width of the stringer, roll the old stringer over to its side and raise and work it over the chord and on to the caps. The new stringer is placed by reversing this operation.

A method of strengthening the chord involving much less labor consists in adding an additional stringer on either side of the existing chord. It is not, however, good practice to leave partly decayed timber in a bridge because of the fire risk.

In renewing isolated ties, remove the adjacent deck bolts and pick up the track about 6 in. Place a 4-in. by 4-in. stick about 10 ft. long across the stringers on each side of the tie. These may be held in place by wedging under the rail or other means and should project on the side toward which the tie is to be moved. Rollers are slipped under the tie and it is rolled out until it clears the rail, when it can be lifted up on to the track and disposed of. Where a number of ties are to be renewed, put in all the new ties in one place and spot in the good second-hand ties where needed. In such cases it is usually necessary to take up the guard timbers where the new ties are put in. Another method is to raise one rail higher than the other, slip the ties out to clear the low rail and then back and over the low rail.

It is usual to lay guard timbers in position and mark the location of the ties. The daps are then cut in them, either on the bridge or the bank, and the timber placed in final position. It is the practice of one road reporting to this committee, where more than 50 ft. of guard timber is to be replaced, to measure the tie spacing on the bridge and dap the timbers in the shop.

Method of Renewing Bridge Timbers.—The year's program for timber bridge work having been determined, it is usual to do all the driving in advance and let the pile driver crew return later to place the timber, or have this work handled by other crews. A minimum of pile driver and work train service is thus secured. After locating the bents to the best advantage relative to the waterway and clear of existing bents, and marking their location on the rail, the guard timbers are taken up, the ties are shifted to clear the new bents and driving is started. It is usual to work backward on a bridge. The work will proceed more rapidly if piles are distributed on the ground in advance. After driving the piles, the ties are re-spaced as well as is possible and guard timbers are relaid, cutting out the spacers where necessary.

When the bridge crew arrives at a bridge where the piles have been driven as above, the first step is to straighten and line up the piles. This may be done with jacks and steamboat ratchets and the piles should be held in position. If badly out of line, this work should be done with the pile driver before it is moved from the job. After marking the grade, usually obtainable from the track, and attaching a guide board the piles are cut off. The stringers and deck are then raised about 2 in. on the old caps to permit the placing of new caps. The cap is brought in, swung off the deck on to the top of the piles and drifted in place. Sway bracing is next put on and bolted up. With high bents, say over 20 ft., some longitudinal bracing should be put on as the stringers are placed.

As soon as two or more caps are in place measurements for the length of the stringers are obtained and the framing of stringers can be started. This should be done on a level stretch of ground as near the bridge as possible and consists in cutting to length, sizing to depth over the caps, and boring for drift bolts where they are used. Holes may also be bored through one line of stringers in each chord for packing bolts.

Methods of assembling stringers into chords are varied. In most cases one chord is changed out completely before the other one is disturbed.

In renewing a bridge, when the old ties are in bad shape about one-half the new ties are put in between the old ones before placing the stringers. This gives a more substantial deck to work from. The remainder of the new ties are put on after the stringers are changed. Ordinarily ties are put in between the old ties or in groups as traffic permits, after the new stringers are in. Some roads defer this work until all the heavy timber released is picked up to avoid scarring up the new deck.

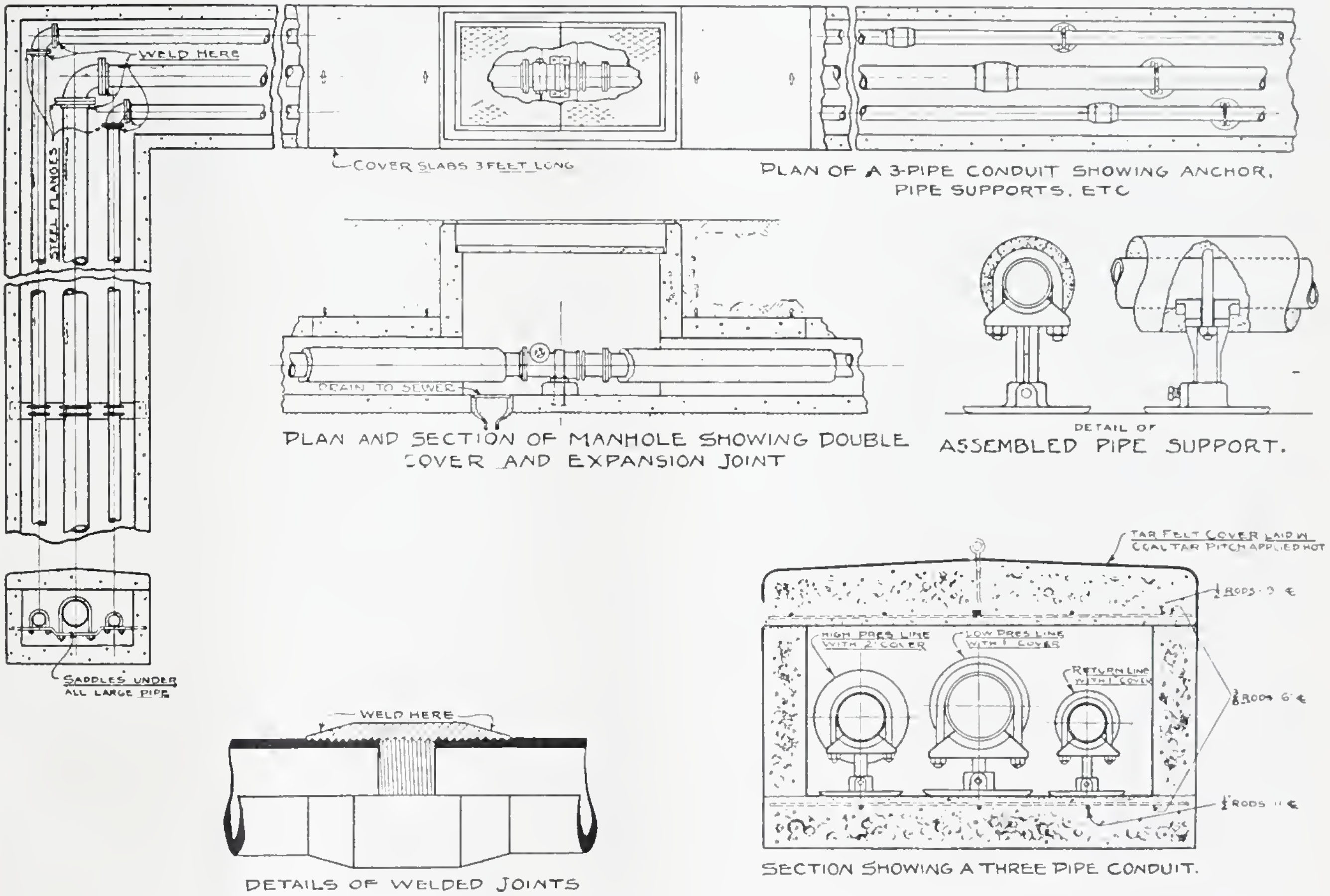
Every bridge gang should have a sufficient supply of the ordinary tools of good quality. Where special tools have been tried out and proven advantageous, gangs should be supplied with them. There can be no argument about the desirability of labor-saving devices at the present time, not only as a means for reducing the amount of labor but for keeping the men employed better satisfied. Among such agencies first place should be given to the motor car and its trailer for handling small amounts of material. Ball-bearing jacks, patent bushed blocks and thin-backed saws are some of the devices that lighten labor and shorten the time for doing the work.

$311,000,000 of Building Contracts Let in October.—Building contracts awarded during the month of October, 1919, in the territory north of the Ohio and East of the Missouri rivers, amounted to $311,382,000, according to the F. W. Dodge Co. This was greater than the figure for any previous month of this year. This was an increase of $76,801,000, or 33 per cent over the total for the month of September, the September total having been somewhat less than that for August. Of the total amount for October, 34 per cent, or $105,663,000, was for residential buildings; 25 per cent, or $78,249,000, was for industrial plants; and 15 per cent, or $45,939,000, was for business buildings. Public works and utilities amounted to $42,334,000. The October figures brought the total for contract awards for the first 10 months of 1919 up to $2,111,452,000 which is greater than the total for any entire year previous to 1919. In fact, these figures indicate an actual volume of building operations during the first 10 months of 1919 somewhat greater than the actual average annual volume for the five years previous to 1919.

Uneven Coatings on Wood Cause Warping.—Coatings of equal moisture resistance should be applied to all surfaces of a wood product which would give dissatisfaction if it were to warp in service. Tests at the Forest Products Laboratory have shown that even when wood is properly kiln dried no coating entirely prevents it from picking up or giving off moisture and, consequently, from swelling and shrinking under the influence of varying atmospheric conditions. Varnish, shellac, and other moisture-resistant finishes merely decrease the rate at which the moisture changes in wood occur. The higher the grade and the more coats applied, the slower will be the moisture changes. Unequal coatings on opposite surfaces of a wooden article cause unequal rates of change in moisture content and hence unequal shrinkage on the two sides of the piece. The result is that the wood tends to cup or twist out of shape.

New Method for Installing Underground Steam Pipe Lines

Underground pipe lines for the distribution of steam or hot water for heating buildings or for other use should be installed with greater care than those located in tunnels or basements where they are accessible for inspection and repairs. Being buried in the ground, they are subjected to unusual influences, and their condition is often unknown until total failure makes it necessary to dig up the entire line. This generally happens in cold weather, when the demand for service is most imperative and the inconvenience and expense are greatest. The Department of Engineering of the State of Wisconsin has worked out a new method of installing pipe conduits that has proved very satisfactory. The plan is described by Mr. John C. White, State Power Plant Engineer, in The Wisconsin Engineer, from which the matter following is abstracted.


WELD HERE
STEEL FLANGES
COVER SLABS 3 FEET LONG
PLAN OF A 3-PIPE CONDUIT SHOWING ANCHOR, PIPE SUPPORTS, ETC
DRAIN TO SEWER
PLAN AND SECTION OF MANHOLE SHOWING DOUBLE COVER AND EXPANSION JOINT
DETAIL OF ASSEMBLED PIPE SUPPORT.
SADDLES UNDER ALL LARGE PIPE
WELD HERE
DETAILS OF WELDED JOINTS
TAR FELT COVER LAID W COAL TAR PITCH APPLIED HOT
1/2 RODS 9 ℄
HIGH PRES LINE WITH 2" COVER
LOW PRES LINE WITH 1" COVER
RETURN LINE WITH 1" COVER
3/8 RODS 6" ℄
1/2 RODS 11 ℄
SECTION SHOWING A THREE PIPE CONDUIT.

Typical Details Showing Designs of Wisconsin State Department of Engineering for Underground Pipe Lines.

The conduit is made of concrete, of such size as may be required to accommodate the number of pipe lines, and reinforced as necessary. The bottom slab is laid to grade for any section and is trowelled smooth. The sides are next poured, and the work of installing the pipes may be started as soon as the forms may be removed safely. The cover slabs may be molded while the work of installing pipes is going on. These are generally made in 3-ft. lengths bedded in lime mortar. The top of the conduit is covered with a waterproof material such as tar felt before backfilling the trench.

Anchorage is so arranged that the pipes are permanently held in place at anchor points and expansion is taken either at the bends or by expansion joints. The supports are clamped to the pipes and move with them. They consist of a saddle clamp adapted to engage a round shoe which slides on the floor of the conduit as the pipes move under changes of temperature. Rollers are not used.

Insulation is applied as for exposed work and it is not subjected to mechanical injury nor to the action of water.

Drainage is provided for by making the conduit as nearly waterproof as possible and then conducting such water as does find its way into the conduit to drainage outlets at manholes or openings into the buildings. This water flows along the bottom of the conduit, each section of which is graded for that purpose, and by inspection at the drainage points the condition of the lines so far as water is concerned may be determined. Underdrains are not used.

By arranging the pipes in a horizontal plane either line can be removed and replaced by disconnecting at anchors and connecting points, and uncovering a sufficient length of the trench to permit withdrawal of the section. A line should be attached to the section before it is withdrawn for use in pulling in the new pipe.

Where steel or wrought iron pipe is used, the joints are made up with couplings and the backs of the couplings are then welded up until the section of the pipe that has been cut away by the threading process is built up to the original section of the pipe. The joint is thus equal to the solid pipe in thickness and it is sealed against that leakage which is so persistent a cause of failure in the ordinary construction. Cast iron flanged pipe may be used for low pressure steam or hot water lines. Lead joints can not be used where temperatures change to an appreciable extent.

The illustrations will make clear the essential features of the method without further explanation. The first line was installed about two years ago. It is carrying high pressure steam and there has so far been no trouble of any sort.

Conference to Discuss Wisconsin Highway Program.—The Wisconsin Highway Commission has called a conference of contractors, material men, and manufacturers of machinery, and public officials to discuss the highway construction program for 1920 and to devise ways and means of making it possible to complete the proposed large programs. Prices of labor, work and materials, and methods of construction will be discussed, also all matters pertinent to getting all concerned fully interested in this great problem. All who are interested or who expect to be interested in highway construction in 1920 are cordially invited to attend. The conference will be held in the State Capitol at Madison, Wis., and start at 10 a. m. on Tuesday, Dec. 3d, and will fully occupy the two days.

Quantity Survey: How Quantities Are Used in Bidding*

The first consideration that comes to a contractor's mind is the ability of a surveyor to supply satisfactory quantities. Perhaps the best answer is that it is being done continually by individuals and by some firms specializing in one or more trades. Acceptable quantities must be accurate and they must be in such form that contractors can apply their customary estimating methods to them without difficulty. Accuracy can be attained only by the adoption of efficient methods of checking "take-offs" and computations.

Architect's Instruction Incorporated in Quantities.—Accuracy depends upon the proper interpretation of the drawings and specifications. This is controlled better by a surveyor than by contractors, because it is the sole object of a surveyor to be accurate and he will take nothing for granted either in the drawings or specifications. If they are not absolutely clear and definite he asks the proper interpretation and incorporates the architect's instructions in his quantities with the result that they truly describe he requirements to be met under contract. Contractors' quantities are always variously inaccurate because their men have not the time, opportunity, or desire, as the case may be, to get the architect's interpretation of all doubtful items and through inequality in skill and experience do not perform the operations of scaling and computing with the same degree of accuracy. The result is lack of uniformity in bidding data which is largely responsible for the customary wide variations in bids.

Trade Practices Should Be Followed.—Quantities must be given in the customary units of measurement. Where trade practices are fairly well fixed for methods of measurements, they should be followed even if the resultant quantity is not mathematically correct; but the basis of such computations must be noted so that no bidder will be deceived. Waste is a variable which is the contractor's responsibility to control and it is a factor in estimates which may win or lose a job. In giving net measurements for volumes and areas it is important to give also the "outs" which correspond so that each bidder can include all or none or part of them according to his custom. Quantities for any item of work should be given in such form that they can be priced up in mass or in careful detail. All of a kind should be given together with its distribution floor by floor or story by story. Work of the same class must be segregated according to conditions affecting cost for installation.

It should be noted that no individual can prepare satisfactory quantities for all trades. No man can have the experience required to do so. To prepare complete accurate quantities for a building for all the trades requires the services of an organization of specialized experts in all the building trades working in touch with each other and in co-operation with the architect. A survey organization that is efficient can undoubtedly give satisfactory quantities.

When a quantity survey is made it is supplied to bidders together with the drawings and specifications. Bids are requested for the erection and completion of the building in accordance with these three documents.

Bidders Not Responsible for Quantities.—Responsibility for the accuracy of the quantities is a matter that has to be determined. Regardless of any form of guarantee that the surveyor or architect or owner may put upon quantities it must be recognized that as a matter of business expediency the contractor awarded a contract based on quantities will check the quantities to verify their accuracy and completeness.

There are two ways of relieving bidders of any responsibility for the accuracy of the quantities supplied to them. First, the quantities may be made a part of the contract; that is, it will be specified that any additions to or deductions from the amount of work listed in the quantities will be adjusted in accordance with the specification stipulations governing changes. In this case the contractor will check the quantities as the job progresses and submit claims for any chance inaccuracies that might exist in the quantities. The surveyor as a disinterested party would investigate such claims with the contractor and agree with him as to the proper amounts of work, if any, which justified extra payment. It should be noted that for bidding purposes the contractor is not concerned with the accuracy of the quantities. If he checked them it would be labor wasted for bidding purposes.

Second: Instead of making the quantities a part of the contract and providing for adjustments of chance errors from time to time, most architects and building owners prefer to have the contractor selected for contract consideration either accept the quantities as accurate or take whatever time is necessary to check them before signing a contract. They prefer to have a lump sum contract with a definite upset price rather than to contemplate the possibility of adjustments for claims during the progress of the job. This is more satisfactory in some ways to contractors. If they have checked the quantities they can go ahead with construction with the greatest confidence in the quantity list for purchasing material knowing that every material requirement is completely covered and understood. Any possible difficulties in substantiating claims would be removed. Conditions would be established for a smooth running job assuring the pleasantest relations with architect and owner.

Uniform Quantities Mean True Competition.—When an architect makes uniform accurate quantities available to all bidders, asking for bids based on the quantities and eliminating bids based on any other data, the bidders enjoy several distinct advantages and protective features which are of positive value at any time and if always available would go far to stabilize the contracting business.

Uniformity in bidding data assures that every bid will cover the same amount of work and work of the same quality. With the requirements fixed that must be fulfilled under contract no bidder will win a losing contract through misinterpretation of items and no bidder will lose a contract because some competitor has "left off the roof." Every bidder can "get down to brass tacks" in estimating cost and whatever profit he includes in a bid should be realized if he wins the contract. A basis for real competition would be established where experience, purchasing ability, organization, skill, would have free play. It would stabilize prices more than anything else could because no bidder would be likely to estimate total "cost" very far wrong if he priced up every item of work required, because average costs are pretty well known. At the same time no bidder would be handicapped. Any bidder's particular qualifications for a job would have greater force and be surer of gaining recognition than by the old-time speculative methods. Contracting would continue to be a game for red-blooded men, full of risks; but the avoidable and senseless risks would be eliminated.

Architect Should Present Bill of Material.—Quantity preparation is not the prerogative of contractors. It became fastened on them by habit. Contractors could very well refuse to continue to assume the risks attendant to it. Why should contractors be obliged to carry the risk of determining what kind and what amount of material of various kinds an architect will demand in a building any more than a coal dealer should undertake to calculate how much coal a customer would require to keep him warm during the winter? Quantity preparation is fundamentally clerical work which can be delegated to others. The logical, business-like way to handle that part of a building operation is to have the architect or owner present a list of the requirements of a job and to ask a price for doing just that amount of work.

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*From the Monthly Bulletin of the Associated General Contractors of America. The abstract given above is from a report prepared for the Committee on Methods by Mr. William Graves Smith, president of the Quantity Survey Co., New York City.

Southern California Engineers and Associations Join A. A. E.—By a vote of 116 to 14 members of the Engineers and Architects' Association of Southern California voted to amalgamate with the American Association of Engineers. As a result of the amalgamation the organization will be known as The Engineers and Architects' Association, Los Angeles Chapter, American Association of Engineers.

Heat Insulating Properties of Materials.—A comparison of the heat insulating properties of some of the materials used in fire resistive construction is given in Technologic Paper 130, issued recently by the U. S. Bureau of Standards. Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 10 ct.

Protection of Metal Structures by Painting

Interesting points on paints and their application to bridges are given by Mr. J. R. Shean of the Pacific Electric Ry. in an appendix to a committee report presented last month at the annual convention of the American Railway Bridge and Building Association. An abstract of the paper follows:

Removing the Rust from the Metal.—As a rule, when steel is new, the rust is only light yellow spots here and there, and can be removed with scrapers made from old files turned over at the end and retempered and sharpened. Stiff scrapers and putty knives are also useful at this time. Steel brushes are not of much real value, except to clean dirt and loose mill scale off. Any heavy seed rust which has formed cups down in the steel should be chipped out with a hammer, and the greatest care should be taken to be sure and get all the rust out of this cup so that the clear steel shows in the bottom. Care should also be taken to avoid cutting the steel unnecessarily with the sharp edges of the hammer. The sand blast is a very thorough way of cleaning steel at this time, but it should be followed at once with the first coat of paint, as the surface starts to rust again very soon after the blast is used.

The tools needed for cleaning the work before repainting are about the same as for new work. Light chipping hammers are indispensable for getting the rust scale off. For cleaning the dirt off, a small bunch of broomcorn wrapped with twine makes a very handy tool. After the dirt has been loosened with the broomcorn, it can be brushed off easily with the duster. This saves considerable scraping with the putty knife.

If a structure is properly treated when it is new, there is hardly any need of using a sand blast for repainting. The rust will only show where it is able to push the paint off and these spots should be chipped out until the cup formed by the rust shows the clear steel. Holding the blast on one of these spots until the cup is clear of rust will cause considerable unnecessary cutting of the steel around it. After the rust is cleaned off the bare places should be spotted with good red lead and then painted the same as the rest of the bridge. If this work is done thoroughly there is no reason to expect further trouble from these places, but if it is not, it is only a mater of a short time until the rust will be at its work of destruction again.

The First Paint Coat.—After the surface has been thoroughly cleaned, the next question is what to use for a first coat of paint to give it the maximum protection against the rust getting another foothold. There are several "inhibitive" pigments, most of which are impractical for general use. The one which is generally accepted by engineers as being the most valuable is red lead. This pigment has had many enemies among engineers and painters on account of its tendency to sag and run on vertical surfaces, and to settle into a hard concrete-like mass in the bottom of the container. These faults are caused by an excessive amount of litharge, which sometimes amounts to 30 per cent of the cheaper grades.

In the last few years some lead manufacturers, by finer grinding and reroasting, have reduced the litharge until the United States Government standard is true red lead 94 per cent and litharge 6 per cent. More improvement has been made, however, and now it is possible to buy red lead containing only 2 per cent of litharge and 98 per cent true red lead Pb_3O_4. This makes an ideal paint for a first coat. Being extremely fine, it fills all pores, and brushes out in a smooth, even film, free from voids. It stays in place on vertical surfaces and does not act ropy under the brush.

Another great advantage in using this high grade material is that it can be bought in paste form, saving the time it used to take to mix up the dry red lead by hand. The vehicle with which the red lead is mixed is fully as important as the pigment itself. The merit of linseed oil is too well known to need comparing with any other for this work, although the paint film is much better if reinforced with Japan oil.

Elaborate tests, made recently, have proven that, without reinforcing, an oil film loses from 18 per cent to 23 per cent of its volume in 200 days. This shrinkage of the oil film, which should hold the pigment together, is worthy of serious consideration and Japan oil or anything else which will truly reinforce it, should certainly be used. Japan oil also furnishes sufficient dryers of the right kind, as rosin dryers are a detriment rather than a help to red lead.

The amount of red lead to be used in 1 gal. of vehicle is a question upon which engineers differ. On the Hell Gate bridge, 37 lb. of red lead was used to 1 gal. of vehicle, but this would only be possible with the very finest quality of red lead. The general average for railroad use is about 25 lb. to the gallon of vehicle, or about 17 lb. to the gallon of paint mixed and ready for use.

When steel work is to be red leaded at the fabricating plant, care should be taken to have the specification worded in such a way that no misconstruing of its intention will be possible. In any case, the inspector should make it a point to see that the intention of the specification writer is carried out.

The Last Coat of Paint Should Be More Elastic Than the Preceding One. The coats of paint to succeed the red lead and to re-paint the structure when necessary form a proposition upon which there is considerable difference of opinion. Some authorities insist that a carbon base is the best, others insist that graphite is, while others prefer mineral red or lamp black. Whatever the individual merits of these pigments are, and they probably are all good if applied right, the fact remains that they are all heat attractors. As heat is a first class destroyer, it is hard to understand why it has become such a common practice to use these dark colors. Unless the price of material is the main consideration there is no reason why steel work should not be painted in light colors, as their resistance to heat rays would certainly be easier on the oil film which holds the pigment together, than the dark colors which attract and hold the heat rays.

Canary yellow, pearl gray or light olive green will change an unsightly black structure to one that will at least be more in harmony with its surroundings. These light colors will last enough longer than the dark colors to pay for whatever difference there is in the cost of the two. It may be argued that light colors become unsightly in a short time from dirt and smoke. This cannot be noticed to any extent except overhead on through truss bridges and on overhead bridges, but even if painted black the smoke marks show considerably on this part of a bridge.

The theory to follow when applying the coats which follow the red lead, as well as any other time the bridge is painted, is to have the last coat of paint more elastic than the coat preceding it. This will insure against checking and alligatoring. Some authorities advise putting a little non-drying oil in the last coat, to make a better "shedder" of water. This would appear to be a good plan, provided it finally did dry hard by the time the bridge had to be repainted, so that the next coat was more elastic, thus avoiding the danger of checking.

How to Retain the Bark of Logs Used in Rustic Construction.—For preventing the bark from flaking off logs used in rustic structures, the Forest Products Laboratory, Madison, Wis., recommends the following methods of seasoning and preparing the timbers as the most effectual:

(1) Cut timbers late in summer and score on two sides; that is, cut off narrow strips of bark for the entire length. Pile in shade in open pile to allow thorough circulation of air. Allow timbers to season until following spring or summer before using.

(2) Proceed as in (1), and in addition coat ends, stripped portions, and knots with coal-tar creosote, using one coat a few days after timber is cut and another just before using the timbers.

(3) Proceed as in (1), but do not score bark. When timbers are in place, tack bark on with large-headed nails, placing one to every square foot of surface. Paint heads of nails to resemble color of bark.

(4) Tack or nail the bark on without particular attention to time of cutting or other treatment.

The nailing method has been used successfully by one western company which maintains numerous rustic hotels, and also on a large rustic building erected for exposition purposes.

Guniting Piling With Cement Gun Outfit Mounted on Flat Cars

A cement gun outfit assembled on a 3-car train was employed by the Puget Sound Traction, Light & Power Co. in coating the piling of the waterfront trestle on the Bellingham Division.

The first flat car contained, first, the bin for the sand and compartment for the sacks of cement; then the boxed-in motor for the mixer; further on the cement gun itself. The second car contained the motor-driven air compressor and fresh water reservoir and water pressure tank.

Cement Gun in Operation.

It took about eight men to handle the outfit, including the motorman and conductor of the train. The motorman handled the sand and the conductor operated the cement gun. Two men were needed to place the sand and cement in the mixer, with 1 part of cement and 3 parts of sand, and one man took the mixture away from the mixer and placed it in the gun, one man being used to operate the gun itself. One other man was needed to look out for the machinery and as a helper. On account of the condition of the bed of the Sound, which oftentimes is from 1 to 2 ft. deep, three men were needed on the ground to handle the hose and nozzle.

Before Treating.

After Treating.

In guniting the piles the material was put on in thicknesses varying from a heavy coat of paint to 8 in., depending upon the condition of the pile itself. Where there were any large holes in the piling which had been eaten out by the Limnoria, chicken wire reinforcement was tacked on and the piling brought up to its original size. All piling also was treated to a point just above the high water mark, or as high as the piling has been affected.

So far the work appears to be permanent after having set for about 7 days, and it is almost impossible to break off the thinnest concrete coat with a hammer, and then only after continuous pounding. The length of time necessary to treat each pile varied very considerably on account of the length and condition of the piles. The best record was the treating of 72 piles in 75 minutes, although these were the shorter piling and least affected.

The work is described by Mr. Harry B. Sewell in November Stone & Webster Journal, from which the foregoing matter is taken.

New Type of Cost Plus Contract

An interesting type of cost plus contract, developed by Morrow & Beatty, Ltd., engineering contractors, was used by them in a $500,000 contract for the Southern Canadian Power Co., with results stated to be unusually satisfactory to both the engineer and the contractors. Mr. Beatty of the above mentioned firm has furnished the Committee on Contracts of the Associated General Contractors with the following information regarding his form of contract.

As a prerequisite to success, the owner's engineer and the contractor must have complete confidence in each other, which is really a very necessary element in all cost-plus work. In co-operation with the engineer, an estimate of cost on the proposed work is prepared, using the estimated various quantities of earth and rock excavation, concrete to be placed and similar items as furnished by the engineer.

Based on the estimated cost arrived at in this way, a fee of 20 per cent, or $200,000 on a $1,000,000 contract is named as the contractor's fee for supervising the work and furnishing all heavy plant, with the understanding that part of this sum will be credited to the owner on the completion of the work. When the contract has been carried out the actual cost of the estimated quantities is determined by applying the actual unit costs to them. Ten per cent of this sum then reverts to the owner, leaving the contractor a net fee of approximately 10 per cent, provided the estimated cost of the work was close to the actual cost. Provision is made that the various quantities may be increased by 10 per cent without any additional compensation to the contractor, but the refund to the owner in all cases is based on the original estimate of quantities. A straight fee of 10 per cent is paid on the overrun, if there is any, beyond the increase in quantities provided for otherwise.

On a $1,000,000 contract, then, if the estimated cost was exactly correct, $100,000 of the tentative fee of $200,000 would be returned, leaving just 10 per cent for the contractor. If the actual cost of the work covered by the estimate amounted to $1,200,000, then the refund would be $120,000, which would reduce the contractor's fee to $80,000. Conversely, should the work be performed for $800,000, the contractor would retain $120,000. In the former case his fee would be only 6⅔ per cent of the cost, while in the latter he would receive 15 per cent.

While this plan is in effect a fixed fee proposition, with a bonus and penalty clause, in actual practice it offers a very simple way of expressing the agreement as to the fee to be paid for the work. It is to be 20 per cent of the estimated cost agreed upon in advance, less 10 per cent of the cost of the work, be it $1,000 or $1,000,000.

The greatest value of this type of contract has been found to be its effect upon the attitude of the workmen and even of the contractor himself. From the very start the contractor's men can very easily understand that for every $10 spent on the work, $1 comes from the contractor's pocket, and that for every $10 saved, there is a profit of one-tenth that amount. While the same condition is met on bonus-and-penalty types of cost-plus contracts, the contractor's direct interest in keeping down costs is not always so apparent to the men in his organization.

Half a Million Buildings to Be Rebuilt in France.—Statistics prepared by M. Lebrun, Minister of Liberated Territories, there are 550,000 buildings to be rebuilt in devastated districts of France. About 300,000 buildings were totally destroyed, and 250,000 were destroyed in part.

The Engineer's Respousibility for Efficient Government*

By FREDRICK P. GRUENBERG,
Director, Bureau of Municipal Research, Philadelphia.

From the beginning of our republic all kinds of administrative public offices have been filled for the most part by lawyers. A great majority of the presidents of the United States have been lawyers; here and there an occasional general; some few gentlemen farmers; but never a technical man. Nearly all the governors of the states in the history of the republic have been lawyers. In every congress from 60 per cent to 90 per cent of the members have been lawyers; and not only in the conspicuous elected positions but also in the important appointive positions, where running for office is not necessary, our legal brethren have out-numbered all other professions and occupations by something like seven or eight to one. President Wilson said somewhere in his numerous writings, when he was a political scientist and before he became a statesman, that the reason for the overwhelming presence of lawyers was that the early problems of our government were primarily legal. Now, without taking issue with so eminent an authority as President Wilson, I do not think that the reason was because the early problems of government were more legal than those of today, for if you will look at it analytically you will find that there are now more legal problems than ever—cities itching for new charters, every state thinking how to revise its constitution, and so on. These are, of course, primarily legal problems.

Problems of Government Increasingly Technical.—It is perfectly clear to anyone who thinks about government at all that the monopoly of public office is not so exclusively the lawyer's as was formerly the case. It is not, I venture to guess, because the problems are less legal, but because the problems of government are being recognized as increasingly technical.

Of course, the war, in common with a great many other things it has done, has given the general public its first real appreciation of the engineer. Not only have engineers been indispensable in the purely military and naval fields, but the aspect of the war that involved production brought the American engineer as never before into prominence. Just prior to our entry into the war a careful study was made of engineers in all kinds of public service, and while I am not going to indulge in any statistics, it will probably amaze engineers to know that in 1916, when the last data were available, less than one-half of one per cent of the government were engineers. We think of engineers as being increasingly influential and important in government, and such is the case; but it shows how little progress has been made, when we realize that about three years ago the percentage was so low. Of course, in a sense that is not a fair calculation because in "public service" we include clerks, stenographers, janitors, and messengers; but, on the other hand, we also include among the "engineers" young cubs who are merely rodmen and who do assistant's work. But while we may safely conclude that the engineers had not begun to break into public work in great numbers, nevertheless, the engineers' influence in government work prior to the war was very great.

The City-Manager Form of Government.—Because of the limitations of time, let us confine ourselves to the municipal side of government, which comes closer to all of us after all, and has more to do with our daily work. Let us, in turn, consider but one important tendency in municipal government and one that concerns engineers very decidedly. We all recognize that municipalities today are drifting toward the city-manager form of government, and every engineer knows what that implies. The city-manager scheme was not worked out in anyone's brain like the game of basketball, and reduced to paper. This plan evolved out of the exigencies of peculiar conditions, and was evolutionary as has been practically every other form of government.

To go back a little, you will remember that the first big break in the tradition of American city government was when Galveston was overcome by a tidal wave. The authorities had to act in the emergency so they decided it was best to concentrate the responsibility and authority, and accordingly a commission of five was appointed in which commission all powers of local government were vested. It worked in Galveston, and within a few years several hundred cities adopted the commission form of government. Under that scheme, the people elected only a few commissioners and it seemed to be simple and inexpensive. It was not long, howtive point of view, was discovered. Under some city charters when commissioners were chosen, they were designated when elected to be the heads of different departments one of public safety, another of public health, another of education, perhaps. The people, in choosing commissioners, thus did two things. They selected a legislative body which was to determine the city's broad policies and at the same time they were supposed to choose in the same individuals, administrators to carry out executive programs. That did not work. You do not choose the directors of your industrial corporation to be at the head of the plant, nor are the technical heads of the departments expected to function as a board of directors. Presumably you elect your board of directors to represent the broad interests of your stockholders, and you select the heads of the departments in an industrial plant or any kind of technical plant for their professional or trade qualifications.

When the Dayton flood came along and an emergency somewhat similar to that in Galveston arose, they took a leaf out of the book of experience, and decided to get a further improved form of government. It is not quite accurate to say that Dayton started the manager form of government at the time of the flood. The inefficiency of the city government before the flood—the old "federal" form—had started a charter revision movement, but the disaster gave that movement an impetus in the direction of the city-manager form.

Essential Features of City-Manager Government.—What does that form set up? The citizens continue to elect commissioners, but these are the board of directors of their corporation. They are selected for their qualifications as citizens and for their platforms as to policy and what they are expected to do, in general terms, for the town. Then this board selects one man in whom is vested all executive power. You see at once the parallel between that kind of organization and the efficient corporation. That executive selects the department heads. In the smaller cities the city managers serve as heads of some of the departments themselves. The department heads are selected (with or without civil service) for their qualifications for administrative jobs. For instance, if the manager selects a city engineer, he does not select him because he is supposed to be personally well liked or because, say, he favors a liberal recreation policy for the city; the engineer is chosen because he knows the technical problems of that department.

This form brings us down to the last word that has yet been evolved in modern municipal government. So far as I know, nobody has yet been able to develop anything which improves on that form of government, and it is so simple and obvious—now that somebody has thought of it—that it is likely to be the form of government toward which all our cities eventually will strive.

Present and Prospective Growth of City-Manager Government.—There are now some 125 city-manager municipalities, and I hear people in the big cities sniff contemptuously to learn that Dayton, O., is the largest city, thus far, that has the city-manager form. It must be tried out on a small scale before it is tried out on a large scale. Already, however, a number of Chicagoans have a similar scheme which is very promising, and during the Mitchel administration in New York City, there was a program worked out for a city manager. When we get going we can work one out for Philadelphia on very short notice. I want to tell you in the family that when the new Philadelphia charter was drafted, the possibility of demanding a city-manager form of government in Philadelphia in the not-distant future, was taken into consideration, and a great many obstructions were removed.

The vast majority of the city managers in this country today are civil engineers. While I do not know off-hand the exact figures, I am safe in saying that it is exceptional to find an important city manager who is not an engineer of some kind; here and there a mechanical, electrical or chemical engineer, but most of them are civil engineers. I attended two of the annual meetings of the City Managers' Association and was very much impressed. I have talked with one of the greatest American authorities on structure of government, and he had one fear for the city managemen:

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*From the Journal of the Engineers' Club of Philadelphia; an address Sept. 16 before the club.

movement—that it is threatened with failure because there are not enough competent men to fill the jobs when created. That does not mean that there are not plenty of engineers willing to take a position paying $3,000 to $10,000 a year, but that there are not engineers who would find themselves equal to, and willing to take administrative jobs with these responsibilities.

Now a charter technic has been worked out and the city-manager form of government is the last word. We are agreed that that means a constructive solution. At the same time, students of the question fear that the movement is threatened with failure, attributing that threatened failure to the fact that there are not people prepared to take the responsibilities that go with the jobs. In a nutshell it is an engineer's responsibility. It is true that engineering is not the whole of government. I do not come to The Engineers' Club to say that the engineer is the only person who has the only key to democracy in his hands, any more than in addressing a teachers' association nor a physicians' association do I offer them similar flattery. In our municipal government, more especially, the way has to be paved by the engineer, because the engineer, not the lawyer or politician, has the qualifications for doing the kind of work now most needed.

The Engineer's Compensation.—Of all the trained professions, the engineer is admittedly the poorest paid. There is an economic reason why that is true. It is because a large proportion of the engineers fill salaried jobs and the opportunities for consultants and for men practising or going into business on their own account is relatively small, while the lawyers and the physicians immediately hang out their own shingles. So far as compensation is concerned, the engineer who is an employee is at a disadvantage. The biggest returns naturally go to the employer. That is true in spite of the fact that engineering is one of the two most thoroughly prepared of the professions—the only one which can compare with it in the demands it makes is that of medicine. If you get a physician as a salaried man in any kind of work in which a certain professional standard is required, you have to pay him more money than you do an engineer for about the same responsibility. Nevertheless, engineering continues to attract promising men. Why is it that we have usually been able to hand out only the poorly-paid routine kind of jobs to them? Usually it has been a salaried position with some corporation in which there is but small opportunity to rise and in which the great majority are kept below the "success line"—for instance, an income of $3,000 or $4,000 a year would probably be widely accepted as an arbitrary line. Above that line let us call the engineer a success. It is amazing how many there are below that line as compared with those above. As a rule, engineers in the public service have been a little better off in that there is a certain continuity of tenure.

Essential Qualifications for Public Service Engineers.—The time has come for engineers to realize this situation, and it gets down to a problem of "What is there in it for me?" for the young man. Engineering courses are being crowded with new things. Columbia feels that there ought to be more complete and longer courses. A great many engineering educators would like to see a man go to college and get everything, just as the physician and the lawyer gets the academic preparation before his purely professional course. Most men find it hard enough to go to college for 4 years not to mention 6 or 8 years. Nevertheless, you do not want an engineer to come out knowing merely the technic of his profession and not having any cultural background. Such a graduate is at a disadvantage mixing with men of affairs and coping with the problems involved in big issues.

I cannot see any special value in giving a man who wants to be a civil, mechanical, or electrical engineer a large dose of Greek. He may want it and he may be interested in Greek, but we must realize that the essentials required of engineering students are covering more and more ground, and what shall we put in the curricula?

Let me make a plea for one group of subjects that for public service are essential. If we are going to get the engineer into a position where his attitude, based on scientific facts and not on personal bias, is going largely to determine our public policies, we have to fit him with some of the equipment that the lawyer has frequently had. The lawyer, especially if he has had a college education, has often been fairly well posted, on history and on economics, political and social conditions. The engineer has been the man of figures but not the man for administration. If it becomes necessary for him to serve in an administrative position you have to consolidate in one person two rather irreconcilable mental types. He has to be a technical man as well as a leader. Otherwise his position must always be a "staff" position and not a "line" position, to use the figure of speech of the Army. We must develop line men as well as staff men.

I have had occasion to engage engineers and many splendid young men have I interviewed. Try yourself to engage an engineer for an administrative job in public service or in a position calling for constructive criticism of public service, and you will find out how few men in your profession know what is going on in the political or economic world. You will find, I fear, that the engineer's interest in big social movements and their significance is usually rather less than the lawyer's and the physician's. It is up to the engineers themselves, it seems to me, with so large a number of engineers going into the public service. And so, when they consider the curricula of the engineering schools, to which society must look for the most of this new administrative material, above all things do not let them eliminate the social sciences. Eliminate languages, if necessary—although I think a knowledge of Spanish, French or German is highly useful. Depend upon such translations as you can get, but do not eliminate the social sciences, if the engineer is to attain the place of leadership which I have tried to describe.

The Public Service Engineer of the Future.—The public service engineer of the future will have to be a many-faceted man. He will have to be a well-rounded technical man if he is to be a city manager, so that he can know the meaning of his problems. He will have to be a man who will know what government stands for as a social force, so that he will be a leader instead of a follower in public service. Take municipal government today; it is the most costly of all of our governments, much more costly per capita than the national government. State governments are not comparatively costly at all, nor is county government. City government undertakes the most elaborate services, and those that come most closely home to us, in that the local government is the one most concerned with providing for the safety, health, education, recreation and convenience of the people.

Just analyze any one of these aspects and you will see the place of the engineer. If you talk to the layman of public health, he immediately thinks of the physician, but the bedside physician is rarely competent to discuss questions of public health. He is a layman in that field. He knows the diseases; he knows pathology and materia medica, and the physiological manifestations of the human body when diseased, but he does not necessarily know public health. Public health administration is increasingly an engineering consideration—concerned not only with quarantines and vaccinations, but with such matters as water supply and the disposal of waste. Nowadays the fact that a man has M. D. after his name does not in itself qualify him as a public health official at all. You will find such positions more and more taken over by men with an engineering equipment.

Take public safety, as another illustration. Of course, that field is often thought of as confined to policing and providing fire protection for cities, but the engineering considerations are very considerable. Other aspects of safety involve such things as boiler and elevator inspection, moving picture inspection, and while the actual inspections are often well done by skilled workmen, the determination of standards of safety involves questions of engineering.

Reference to the modern city's bridge-making activities and road-making activities is hardly necessary, but these are essential factors in efficient municipal government. Even in the realm of the public school the engineer has his indispensable post of responsibility. Teaching schools is a profession with which the engineer as an engineer has nothing to do, but the problems of housing school children and providing heating and ventilation are not for the pedagogue to work out but for the architects and engineer. Further illustrations are available but are surely not needed.

Summary.—The thing resolves itself down to this: with the increasing complexity of government a trained public service is indispensable. If democracy is to succeed, the old tradition of putting the politician in the technical administrative post must soon cease, and democracy must look to the professional public servant to take up the burden. Nowhere is there thus far developed a nucleus for such a professional group in America to such an extent as in your profession, and I would plead with you, therefore, not to miss this opportunity of two-fold attractiveness; first, to serve our communities in posts of unique importance and responsibility, and, second, to afford professional careers comparable with the best in the other professions in the opportunities offered for material reward and in the esteem of fellow-citizens.

New York City Regulations for Outside Storage Tanks for Fuel Oil

The Board of Standards and Appeals of New York City, after study and investigation extending over a period of 5 months, on Nov. 6 adopted rules governing the storage and use of fuel oils and the construction and installation of oil burning equipment. The regulations regarding outside storage tanks include the following:

Storage Tanks Located Outside of Buildings Within Fire Limits.—Within the fire limits, tanks to contain fuel oil for use on the premises, and of a capacity and at distances specified below, may be placed above ground outside of the building if such tank does not exceed 15 ft. in height above the surface of the ground and if completely enclosed.

Distance to nearest building in feet not exceeding	Capacity, gal.
40	71,400
30	40,800
20	30,600
10	20,400
5	10,200

If such service tanks are entirely buried and roofed below the surface of the ground, the capacity in gallons may be increased by 200 per cent.

Outside General Storage Fuel Oil Tanks Located Above Ground Within the Fire Limits.—Such general storage tanks located within the fire limits shall not exceed 25 ft. in height, shall be built of metal, and shall be surrounded with a dike of unpierced masonry or reinforced concrete not less than 4 ft. in height, with a capacity of at least that of the tank to be protected. The walls and floor of such dikes must be continuous, and oilproof and waterproof, and must not be built within 10 ft. of the walls of the tank. If tanks are placed in battery the dikes shall be rectangular in shape, and the dike wall separating them as well as the dike wall within 100 ft. of any structure, shall be carried up as a fire stop to a height of 4 ft. above the head of the tank and coped with stone or concrete, and any openings in walls above the dike shall have automatic fireproof doors.

The capacity of any such single general storage tank within the fire limits shall not exceed 100,000 gals., and the gross capacity of storage shall not exceed the following tables:

To line of adjoining property or nearest building (ft.).	Gal.
75	100,000
100	150,000
150	250,000
200	500,000

Such general storage tanks may have extra fill and emptying connections as the Fire Commissioner may determine.

Outside General Storage Fuel Oil Tanks Located Outside the Fire Limits.—Such general storage tanks shall be protected by dikes and fire stops as provided in the previous paragraph, shall not exceed 35 ft. in height above the ground, and may be constructed either of metal or of concrete reinforced with steel in order to resist the oil pressure.

If built of concrete, the walls and floor of such tanks shall be continuous and shall be not less than 8 in. thick, mixed in the proportion of 1:1½:3. The walls shall be of sufficient thickness so that the tensile stress, disregarding the steel reinforcement, shall not exceed 150 lb. per square inch. The horizontal and vertical reinforcement shall be properly proportioned and placed to provide for expansion and shrinkage without leakage, and the stress in the steel shall not exceed 10,000 lb. per square inch.

As soon as the concrete has hardened sufficiently to be self-sustaining, the forms shall be removed and all cavities filled with 1:1 mortar thoroughly rubbed in and all irregularities trowelled smooth.

The concrete shall harden at least 28 days before use, and the surface of the floor and the interior surface of the walls shall be protected by coating with a sodium silicate solution or other equally good protection to prevent oil coming in contact with the concrete.

The maximum gross capacity of any such single tank when situated outside the fire limits shall not exceed 250,000 gal., but the gross storage capacity may be double that specified in the tables for above ground tanks within the fire limits, and when such tanks are placed at least 250 ft. from the line of adjoining property or the nearest building, the gross capacity may be unlimited.

Material and Construction of Metal Tanks.—All fuel oil storage tanks within the fire limits shall be constructed of wrought iron, galvanized steel, basic open hearth or electric steel plates of gage corresponding to the capacity as specified in the following tables:

TANKS PLACED UNDERGROUND.

Capacity in gal.	Thickness of material U. S. Gauge.
500	14
1,000	12
5,000	7
10,000	¼ in.
20,000	5/16 in.
30,000	⅜ in.

TANKS PLACED ABOVE GROUND.
(Horizontal.)

Maximum diameter in feet.	Thickness of material U. S. Gauge. Heads.	Shell.
5	7	10
8	¼ in.	7
11	⅜ in.	¼ in.

TANKS PLACED ABOVE GROUND.
(Vertical.)

Diameter, ft.	Thickness of material, U. S. gauge. Top.	Top ring.	2d ring from top.	3d ring from top.	4th ring from top.	5th ring from top	6th ring from top.	Bottom.
40 and less	10	7	7	7	5	3	2	10
45	10	7	7	7	5	3	1	10
50	10	7	7	7	1	1	0	10
55	10	7	7	6	3	1	2-0	10
60	10	7	7	5	2	0	2-0	10
65	10	7	7	5	1	0	3-0	10
70	10	7	7	4	1	2-0	4-0	10
75	10	7	7	4	1	2-0	4-0	10
80	10	7	7	3	0	3-0	5-0	10

Tanks of greater capacity than above shall be proportionately heavier and of sufficient thickness to safely hold the contents.

All joints shall be riveted and caulked, brazed, welded, or made by some equally satisfactory process, and the tanks braced sufficiently to withstand all stresses due to transportation or use. All riveted joints shall have an efficiency of not less than 60 per cent.

The top cover shall be of the same material as used in the construction of the tank, permanently secured to the tanks without other openings than provided for in these rules. A safety valve shall be installed on all tanks placed outside of buildings.

All outlets and inlets shall be through the top or cover of the tank, except for the clean-out plug, and in general storage tanks a water drain not exceeding 1 in. diameter may be permitted.

All metal tanks shall be thoroughly coated on the outside with tar, asphaltum, or other suitable rust-resisting protection. When buried in soil impregnated with corrosive materials, steel tanks shall be entirely covered with a 2-in. thickness of cement mortar or shall be of heavier metal, in addition to being protected as specified.

All above ground storage tanks exceeding 200,000 gal. capacity shall be provided with approved explosion hatches having a combined area of not less than 1½ per cent of the roof area of the tank.

All tanks shall be tested and must withstand a pressure of not less than 25 lb. per square inch shop test.

Man Failure Cause of 88 Per Cent of Industrial Accidents.—According to a bulletin of the U. S. Division of Safety Engineering, 88 per cent of the industrial accidents are not directly chargeable to machinery, but are due to man failure. It also is stated that of the 38,000,000 working men and women in the United States, 700,000 each year lost limbs or are laid up for an average of 4 weeks each, resulting in a monetary loss to wage earners aggregating $50,000,000.

Concrete Arched Beams and Open Girder Carry Roof of Toronto Theater

The Bloor Street Allen Theater, Toronto, has several interesting features, especially in the use of reinforced concrete. The structural elements of the roof and balcony were designed by F. G. Engholm & Partners, on the Hennebique System. The following description of these features is taken from the Contract Record:

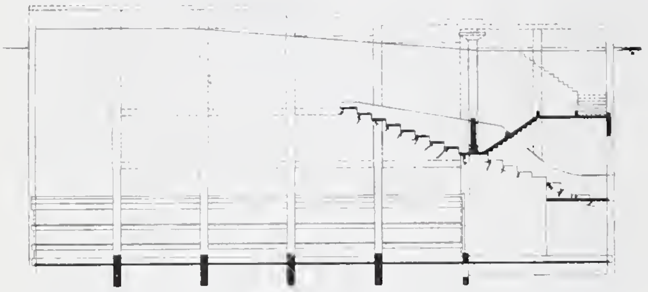


Fig. 1—Longitudinal Section of Theater Showing Roof and Balcony Construction.

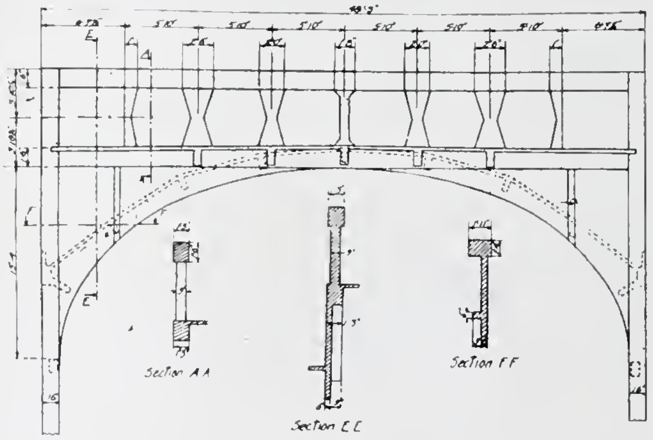
Supporting the roof are four arch beams and one "open" girder, as shown in the longitudinal section in Fig. 1. This "open" girder beam is about 25 ft. from the rear wall of the auditorium and forms one support of five longitudinal roof beams which span that distance and are carried at the other end by the brick bearing wall. It also supports, in suspension, the ends of nine longitudinal roof beams spanning a distance of about 13 ft. 8 in. to the first arch beam. This type of girder, developed by Francis Hennebique, is of open or hollow construction, as shown in Fig. 2, and has the advantage of light weight, combined with maximum strength and rigidity. It has a clear span of about 46 ft. and is about 7 ft. 6 in. deep, projecting above the roof all but 18 in. of its depth.

The main advantage of the girder is that there are no diagonal members in this construction. This greatly facilitates the reinforced concrete work, as the members, being vertical, can be constructed in the same manner as ordinary reinforced concrete columns. The method of constructing this type of beam is usually as follows: The whole of the reinforcing steel is placed in position together with the necessary false work supporting it. The full form work is placed for the bottom chord, which is poured together with the roof slab. The form work is then placed for the upper portion of the girder and the vertical members are poured, after which an interval is allowed before the pouring of the upper horizontal member, in order to provide for any shrinkage in the concrete.

The four arch beams are at about 13 ft. 8 in. centres and are all of the same design. They support, and are monolithic with, the nine longitudinal beams, which carry the roof. Figure 3 shows the form and dimensions of these beams. They have a clear span of about 46 ft. without ties of any kind. The rise of the arch beam is 15 ft. 4 in., and the greatest depth of the beam at the center is 5 ft. 6 in. The arch treatment of the roof in this way is somewhat unusual and gives the interior of the building a very pleasant architectural appearance.

The balcony, as shown in Fig. 4, is a large reinforced concrete cantilever, 25 ft. in the clear, anchored to the brick bearing wall at the rear. Its greatest depth is 5 ft. 10 in., at which point a transverse beam is formed, resting on four reinforced concrete columns, which, together with two columns in each side-wall, support the weight of the balcony. Where the reinforced concrete takes bearing on the brick work, it was poured directly on the brick work, after the latter had time to dry out. The anchored portion of the balcony, from the rear wall to the four supporting columns, is 22 ft. 9 in., while the overhang is 25 ft. in the clear, giving the balcony a total depth of 47 ft. 9 in. The anchored portion of the balcony is 11 ft. 8 in. narrower than the rest of the house, having a width of 36 ft. 7 in. All treads are 3½ in. thick.

The foundations of the building are of reinforced concrete beam construction and the remainder of the structure is masonry. Where the roof beams project above the roof surface, the concrete is protected from any possible deteriora-



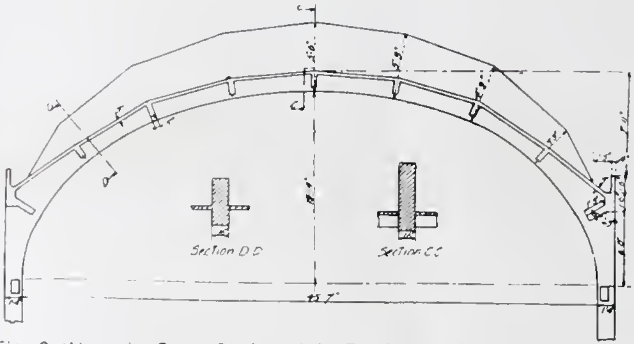


Fig. 2 (Upper)—Open Girder of 46 Ft. Span. Fig. 3 (Lower)—Details of Arch Beams.

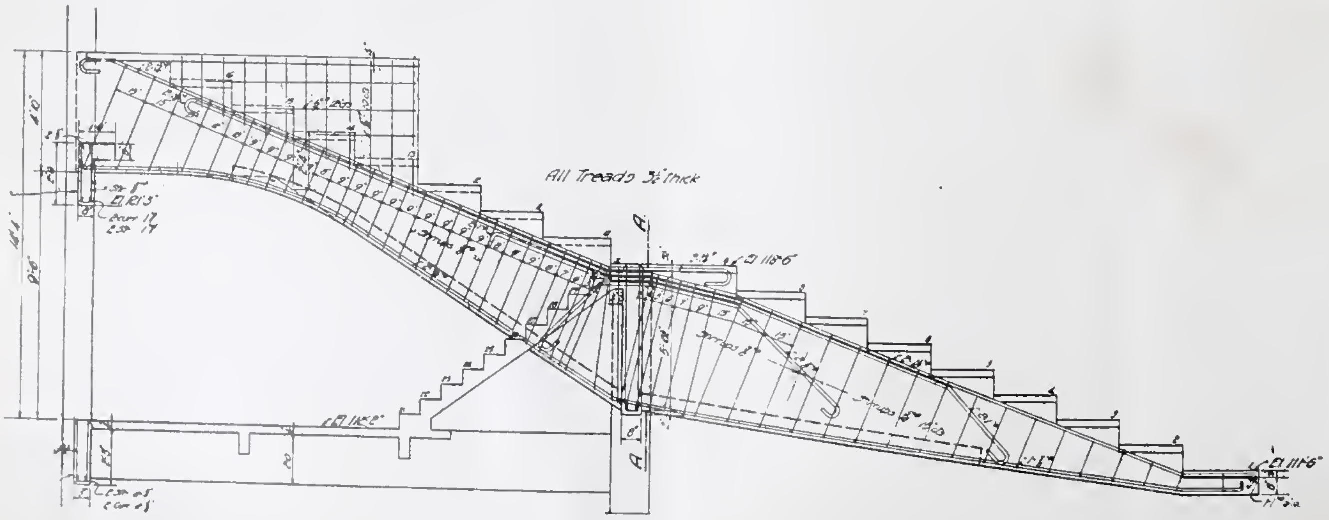


Fig. 4—Concrete Cantilever Carrying the Balcony.

tion through the action of frost, by the use of waterproof paint.

The designers of this theater have secured a very pleasing interior appearance, using rich ornamental plastering, with pilaster and panel wall effect. The ceiling follows the arch lines of the concrete trusses.

The chequered work at the prosecenium arch is especially fine. On each side of this arch are two curved boxes, as a conventional feature of a theater, which are used in connection with the heating and ventilating system.

The theater is ventilated by means of electric suction fans which draw in pure air from outside through vitrified ducts under the auditorium. For heating purposes this air is passed through heated coils in the basement before distribution. In the roof are exhaust fans which draw out the impure air, insuring a constant replacement.

The architects of the building were Hynes, Feldman & Watson.

Methods of Inspecting Railway Bridges

The present bridge inspection methods of railway companies were outlined in a committee report presented at the 29th annual convention of the American Railway Bridge and Building Association held at Cleveland, Oct. 21-23. The report dealt only with inspection as involved in current maintenance from year to year. It was based largely on replies to a questionnaire received from 40 railroads having a mileage of 90,000. An abstract of the report follows:

Inspection of Metal Bridges.—An annual inspection of metal structures is more generally in effect than that of any other periodicity, while the officer conducting it is more frequently chosen directly from the staff of the chief engineer than from any other group of officers. The motor car seems to be the most common means of locomotion for the inspection party, and the tools used for metal bridges consist generally of rivet hammers, calipers, rules and tape measures.

Regular forms for taking and recording notes in the field are used by the greater number of railways. These forms are diversified in character, ranging from ordinary mineograph forms to bound notebooks. Some roads require notes to be taken in detail, others contemplate the record being made in narrative form. Many of the forms seem to cover the matter very comprehensively, while others are painfully lacking in provision for adequately making the requisite notes.

By far the greater number of railways make inspection separately for the various members of metal bridges and it is probable that the general appearance of the structure and the judgment of the inspector are the criteria as to whether actual measurements are necessary. In most cases recommendations as to repairs and renewals are made at the time of inspection and are recorded with the notes, but with metal bridges it is more than likely that such recommendations are appended to the inspector's report after mature consideration has been given to conditions reported at the office.

Generally the inspection notes are copied before being filed and the disposition of the notes is extremely diversified. In some cases careful calculations are reported as being the method of determining changes in the carrying capacity of the structure, but in other cases no such calculations or other investigations are customary. Almost all carriers report the practice of comparing records of previous inspections with conditions found, in an effort to determine the progress of deterioration.

Inspection of Wooden Bridges.—Entirely different results are to be expected from the effects of climate on wooden bridges than with metal structures, but no definite statement can be formulated as to the general effect of climatic conditions in the periodic inspection of wooden bridges for railroads in the same territory differ as to the frequency of inspection. A tabulation of returns shows the periodicity of inspection and the percentage of total mileage reporting under that periodicity as follows:

	Per cent.
Annually	41.55
Semi-annually	32.22
Three times annually	5.95
Four times annually	2.62
Six times annually	[illegible]
Monthly	[illegible]

Nearly 75 per cent of the mileage represented in the replies to the committee's letter of inquiry customarily use the motor car as a means of conveying the inspection party over the line, while only about 21 per cent use regular or special trains. The tools generally used for the inspection of wooden bridges consist of a special inspection bar and testing auger, although in some cases a chisel and brace and bit are added to the tool equipment.

Regular forms for recording inspection notes in the field are used by 85 per cent of the mileage represented in the returns to the questionnaire. Actual measurements are reported as being taken by 52 per cent of the reporting mileage, while general appearance and judgment are used by the remainder. By far the larger portion of the lines record in the notes recommendations as to repairs and renewals at the time the notes are taken. While 85 per cent of the reporting mileage use regular forms for the reports, there is no uniformity in the manner of handling the notes when completed or the final disposition thereof.

General practice is about evenly divided as to giving authority to the inspector to order repairs or replacement in distinction from simply making recommendations as to these matters. The officer most often made responsible for bridge inspection is either the supervisor or the superintendent of bridges and buildings.

Conclusions of the Committee.—A well organized plan of thorough and periodical bridge inspection should be in effect on all railroads. Inspection should preferably be made semi-annually and in any event not more infrequently than annually.

The inspector should be particularly fitted by training and experience for the work, technical training being requisite for metal bridges and both judgment and experience for wooden structures.

Motor cars afford the best means of conveying the inspection party over the line.

Such tools, either special or standard, as he may consider useful for his purpose should be furnished the inspector.

Special inspection forms for taking and recording notes are essential. Adequate provision should be made for reporting the conditions of bridge members individually or by groups and classes, dependent upon the facts disclosed by the examinations.

Sufficient assistance to insure thorough and comprehensive examination of a structure should be supplied.

Where necessary to determine the extent of deterioration, actual measurements of members should be made.

Recommendations of the inspector as to corrective measures which should be applied to observed conditions are not only desirable, but practically necessary. These recommendations should be recorded in the notes at the time of inspection and upon its completion should be followed up through proper channels for necessary action thereon.

The inspector should be vested with authority to order through proper channels the correction of any imminently unsafe condition discovered.

Prescribed limitations in stress should, if possible, be established, especially for metal bridges.

The general program of inspection can best be formulated by the individual railroad and must needs be developed by a consideration of the operating organization in vogue, methods of effecting repairs and renewals and the number, magnitude and character of bridges maintained.

At least one complete counterpart of all notes, recommendations, records and papers pertaining to the inspection and corrective measures applied as a result thereof should be kept in one file of ready access.

Bridge Inspection Tools.—Bridge inspectors on the New York Central R. R. are furnished with a ⅝-in. steel bar pointed at one end, to enable them to determine sap-rotten timber, and with a round knob on the other end for use as a sounder to determine interior decay in piles and large timber. A ⅜-in. auger is used to bore into timber to detect dry-rot, particularly in Howe truss members. For the inspection of steel bridges the inspectors use a steel bar to break off heavy rust and sometimes use the head of the bar to detect loose rivets, although these usually show red rust quickly.

Disadvantages of Skyscrapers

Although city dwellers point with pride to the skyscrapers, yet, as Mr. V. D. Allen, in a paper before the Cleveland Engineering Society, points out, they do not necessarily denote the greatest civic development of our cities. He carefully enumerates all the disadvantages, and there as so many, that perhaps the advantages are not worth while.

The greatest evil resulting from tall buildings is probably that of street congestion. A building housing 1,000 people requires the use of 12 to 15 street cars to take them to and from work. And this thousand fixed users would not include the several hundred transients. Such a building does not occupy an entire city block. The congestion produced when entire city blocks are so improved can better be imagined.

A traffic count in New York shows us the startling effect of congestion. On 5th Ave. and 42nd St., from 8:30 a. m. to 6:30 p. m., a period of ten hours, during which time there passed 18,800 vehicles and 137,780 pedestrians, and for the same hours counts taken at ten points on 5th Ave., ranging from 14th St. to 59th St. inclusive, showed an average of 14,096 vehicles and 82,506 pedestrians. "We think of a city having a population of 137,000 as a real town, yet here we have a condition where all the people of a large city pass one point on one street in a period of ten hours, and a mass of vehicles, which, allowing 20 ft. to each one, would make a procession 71 miles long, also passing at the same time. Such vast numbers are more than we can fully realize, and should be of themselves sufficient comment."

Four times daily these persons must enter or leave the building in a comparatively short space of time, which must create an elevator congestion that is both serious and dangerous. Obviously, the wear on the street pavement must be very severe, and the cost of maintaining good streets under such a concentrated heavy traffic is of necessity high. The noise and confusion resulting from so vast a throng of moving people and vehicles is very great, and, according to the medical authorities, produces a noticeably injurious effect on the health of those who are constantly a part of it.

There are many problems of transportation, both of humans and produce, which are created by this congestion.

Besides the congestion above the surface, there is a serious congestion beneath the surface of the streets, for the presence of many large buildings requires an increase in the sewers, water lines and conduits, and other ground service, a well as the constant tearing up of the already overcrowded street surfaces to renew or repair the underground work. Investigation shows that as congestion of traffic on streets increases, the number of accidents increase in about the same, or perhaps in an accelerating, ratio, and of necessity the number of men employed as traffic officers must be increased, another cost that the city as a whole must pay for the privilege of high buildings.

Another effect of congestion is the problem of the feeding of the vast throng of people at the noon hour.

Mr. Allen considers the loss of sunlight at the street surface and to the surrounding buildings is in itself an evil of sufficient magnitude to condemn high buildings. He quotes some figures deduced by the engineers of the New York Commission. They base their figures on the shortest day of the year, which is Dec. 21, at noon, and find that the Adams Express Co. Building, which is 424 ft. high, casts a shadow 875 ft. long. The Equitable Building, which is 493 ft. high, casts a shadow 1,018 ft. long. The Singer Tower, which is 546 ft., casts a shadow 1,127 ft. long, and the Woolworth Tower, which is 791 ft. high, casts a shadow 1,635 ft. long.

Under the same condition, that is, at noon, Dec. 21, at a north and south street, and having buildings on both sides of the street, one and thirty-five hundredths times the width of the street in height, it is claimed that all the windows get some direct sunlight, but if the buildings were increased to one and one-half times the width of the street in height, then but 90 per cent of the windows will get direct sunlight, and as the height of the buildings are increased the amount of windows getting direct sunlight decreases rapidly until when we have buildings six times the width of the street in height, the percentage of windows which receive direct light is reduced to 22½.

Not only this, but under the same condition a window which has a building on the opposite side of the street one time the width of the street above it, has direct sunlight entering it but 12 per cent of the time that the light would enter an unobstructed window.

There is also the cost and maintenance of light and the inferior product resulting to be added to the economic wastes chargeable to high buildings. The air in the streets, courts and yards which are flanked by high buildings into which but little direct sunlight can shine is, according to the best authorities, injurious to health, since the sun's rays have the power of purifying the air as nothing else can.

Students of high buildings have placed much emphasis on the fire hazard created by these buildings, and while it is an important feature and should be considered, it is in Mr. Allen's judgment not so important an objection to them as has generally been contended. It is true that the fire departments cannot reach a fire which is more than 80 or 90 ft. above the street except by the use of a stand pipe, but the danger from fires in office buildings is very small and can be almost eliminated by the use of fireproof material in their construction and the proper protection of wall and vertical openings by fireproof windows and doors.

The financial side of this question deserves a word. The testimony given before the New York Commission demonstrated that the skyscraper was not a good paying investment. While it is true that one such building standing alone will pay, since it can get its light and air from the surrounding property, yet when other buildings are around it and it has lost this advantage, then its renting value decreases accordingly. In the last analysis, high buildings beget high land values, land values which are speculative in nature, and it remains to be proved that such land values are a benefit to the community.

The Relation of the Professional Technical Man to Civic Progress*

By HENRY K. HOLSMAN,

President Illinois Chapter American Institute of Architects.

How can the professional technical man apply his motive power and his mental processes to civic progress? First of all there must be created a professional class consciousness. The public must be conscious of the nature of the professional mind—the training it has been subjected to and it must be conscious of the extent or numerical strength of the professional class. The professional class must be conscious of itself, and conscious of its ideals and its duty to the whole public, and it must lift higher and higher the banner of service and fix itself immovably upon the principle that public interest must have precedence over self interest.

It is my firm belief that there now exists in this republic a great and powerful professional class. It only needs to be organized to be visualized. It is of the utmost importance, therefore, that the first duty of the professional technical man is organization. The prime object and the principal reason for his organization is class consciousness. We have the ideal of the professional man in abundance, but we have it scattered without organization and without leadership, and without recognition on the part of the public.

An example of the use of the professional class for the public good may be seen in an analysis of the recent conference on industrial conditions at Washington. It was a comparatively easy matter for the President of the United States to summon to Washington men representative of the employe class. It was doubtless comparatively easy to find able representatives of the employer or capitalist class; but one must assume that it was very difficult to find representatives of the public or the middle class, for we find as representatives of the public such men as the head of the great organized steel industry and such men as the head of the oil monopoly attempting to function in a conference of national moment as representatives of a class having no prejudice for or against either the capitalist or the laborer. I venture the assertion that if the professional classes were one-half as well organized and visualized as the laboring class to-day is, or as the capitalist class has been for many years, it would not have been difficult to select from the professional men those who were able to weigh and balance contending principles of the opposing classes, to survey and evaluate the motives of action and reaction and to render a just balance between the two.

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*Abstract of an address delivered Oct. 21 before the civic meeting of the Technical Societies of Chicago.

The need of the professional technical man in civic affairs is exceedingly great. The need of an organization of all of the professional technical men in one great body is equally important and equally urgent. Steps have been taken toward the organization of a federation of all of the technical professional men of Chicago. When this is accomplished it should not stop here. The same process should take place in every city or civic center and those in turn should all be combined in one great national professional body.

The world is fast becoming aware of the great value of the professional man. He is the man who stands ready to serve other men in their health and happiness, in their organizations and enterprises, in all their conceptions and achievements. What great commercial enterprise or what mightly utilization or forces would have been achieved by the so-called masters of industry had it not been for the professional man who patiently and systematically worked it out, practically for the joy of achieving it; or what one of the great machines of finance or industry, or what government in war or peace could survive and develop, but for the continued devotion of the professional man? His services are not paid for in proportion to their value, and for some things he can not be bought. He is born of the people, seldom if ever of autocracy. His equipment is inherited from society and he is the safest and most important trustee for the preservation and development of society the world will ever know.

We are now awakening to the dawn of a new era. The age of kings and princes is past. The day of barons and aristocrats is waning, and the day of professionalism is at hand. Professionalism carries but one banner and written on that banner is but one word—Service. The law of its being is freedom restrained by culture, training and unbiased devotion to duty. The remuneration of its members is a known fee in proportion to the cost of preparation and the hazard of the undertaking, coupled with that distinctive mental exhilaration known to no other calling—the joy of solving a problem that makes life still more worth living.

It is our chief duty to develop our organizations in order to develop our class consciousness. By serving with each other in close contact and fraternity we can develop an awareness of our combined strength and power. To belong is not enough—to participate must be the watchword. When we know each other as individuals, we can make ourselves known to society as a class. We may not have been first in war, but we can be first in peace. Let us stand by the professional ideal, to ourselves be true, and unite in one great body and one great purpose, to serve organized society everywhere within the field of our usefulness, with one great professional organization.

Comparison of Moisture Resistance Tests for Coatings

In testing the effectiveness of wood coatings in preventing the passage of moisture, it might be assumed that immersion in water would be much more severe than exposure to moisture-saturated air. Recent tests at the Forest Products Laboratory, however, showed little difference between the two tests for exposure periods up to 17 days.

Five sets of birch panels with various coatings were tested, first by exposure for 17 days to a humidity of 95 to 100 per cent and later by actual immersion for the same period in water. At the end of these periods, the panels were weighed and the gain in weight taken as the amount of moisture transmitted through the coating.

RELATIVE SEVERITY OF WATER AND HUMIDITY EXPOSURES.

No. of specimens averaged.	Treatment.	Absorption of moisture in grams per square foot in 17 days.	
		Water exposure.	Humidity exposture.
1	Filler + 3 brush coats of rubbing varnish	9.61	7.70
2	Filler + 3 brush coats of spar varnish A	12.60	12.24
2	Filler + 3 brush coats of spar varnish B	19.58	18.82
2	Filler + 3 brush coats of spar varnish C	17.04	12.42
7	Filler + 1 coat of rubbing varnish + 1 coat of rubbing varnish size + aluminum leaf + 2 coats of spar varnish	.59	.45

Conference of Map-Making Organization of the U. S. Government

It may be a matter of surprise to some engineers to learn that there are no less than 14 map-using and map-making organizations of the national government, 11 of which are actively engaged in the work of map making, the remaining three being principally map users rather than map makers. Inevitably there has been some overlap and duplication of effort in the work of these various organizations.

In July of the present year, Engineering Council, an organization of national technical societies of America, addressed a communication to President Wilson, calling his attention to the many and varied needs for maps, and to the lack of co-ordination in the several map-making agencies of the Government. The suggestion was made that in order to expedite the completion of the national topographic map a "Board of Surveys and Maps" should be appointed, consisting of a representative from each of the present Federal map-making agencies, together with representatives from well-qualified map-using agencies, which would be vested with authority to work out a plan of standardization and co-ordination of the work of the Government, and to report the same to the President for such action as he might find wise.

President Wilson referred the matter to the Secretary of War and instructed him to call a conference of representatives of the Corps of Engineers, U. S. A., the U. S. Coast and Geodetic Survey, the U. S. Geological Survey, the General Land Office, the Post Office Department, the Bureau of Soils, the Reclamation Commission, the Bureau of Roads, the Indian Office, the Mississippi River Commission, the Survey of the Great Lakes, and the Boundary Commission.

The following representatives were chosen to meet in conference and submit a report: W. M. Black, Maj. Gen., Chf. of Eng. Corps of Engineers, U. S. A.; William Bowie, Chief, Div. of Geodesy, U. S. Coast and Geodetic Survey; Geo. Otis Smith, Director, U. S. Geological Survey; Frank Bond, Chief Clerk, General Land Office; J. H. Robinson, Chief Clerk, Topography Branch, Post Office Department; Milton Whitney, Chief of Bureau, Bureau of Soils; A. P. Davis, Director, U. S. Reclamation Service; Thos. H. MacDonald, Chief of Bureau, Bureau of Public Roads; W. M. Reed, Chf. Eng., Bureau of Indian Affairs; C. McD. Townsend, Colonel, U. S. Army, Mississippi River Commission; C. O. Sherrill, Col., U. S. Army, U. S. Lake Survey; E. C. Barnard, Commissioner, International (Canadian) Boundary Commission; O. C. Merrill, Chief Engineer, Forest Service; W. C. Asserson, Captain, U. S. Navy, U. S. Hydrographic Office. These representatives met at Washington from Sept. 15th to 29th inclusive and considered and discussed the problem in its several practical aspects. It was early recognized that engineering and scientific societies are vitally interested in the subject of map making and as soon as the conference was organized the following societies were invited to send representatives to the meetings to present their needs: Engineering Council, The American Society of Civil Engineers, The American Institute of Mining and Metallurgical Engineers, The American Sociey of Mechanical Engineers, The American Institute of Electrical Engineers, The American Association of State Geologists, The American Association of State Highway Officials, The National Research Council, The National Geographic Society, The Association of American Geographers, The American Geographical Society, The Geological Society of America.

Ten of these organizations were represented at the conference on Sept. 22, but sufficient time not having been available to formulate and present their views during the conference, it was agreed that the above named organizations would present their recommendations to the permanent body hereinafter proposed.

The following is abstracted from the report of the conference:

What Federal Map-making Organizations Are Doing.—The U. S. Geological Survey is charged with the preparation of a topographic map of the United States, which, with certain minor modifications, will adequately meet the needs for a general utility map. The work of that bureau is progressing as rapidly as the available funds will permit. Approximately one-third of the area of the continental United States, exclusive of Alaska, is now covered by satisfactory maps of this class. The U. S. Coast and Geodetic Survey, in addition to its other work, is engaged in the execution of the primary control in the interior of our country. A basic horizontal and vertical control which will permanently establish some geographic position and elevation within about 50 miles of any point in the United States has been approximately 50 per cent completed. Close co-operation exists between the U. S. Coast and Geodetic Survey and the U. S. Geological Survey so that there is no duplication in carrying out the work necessary for the standard topographic map.

Certain map needs of the Corps of Engineers, of the Bureau of Public Roads, of the Bureau of Soils, of the Forest Service, of the Reclamation Service, of the Bureau of Indian Affairs, and of the Post Office Department are met by the standard topographic maps being prepared by the U. S. Geological Survey. These organizations are not duplicating the work of the Geological Survey and are not engaged on map work of a similar nature except when their necessities demand immediate field work in areas where the maps of the Geological Survey are not available and when there is no immediate prospect of surveys being made by that bureau. All of these organizations require special maps, some of which demand more detailed surveys than those necessary for the standard topographic map and others of which require the collection of entirely different kinds of data. To all of those organizations the early completion of a standard topographic map of the United States is of extreme importance.

The Corps of Engineers has specific appropriations available to reimburse the Geological Survey and the Coast and Geodetic Survey for the cost of making military surveys and close co-operation among these organizations has been in effect for four years so that there is no duplication of effort or expenditure. In the case of the Forest Service specific authority for topographic surveys of National Forest areas is given in the appropriation for the Geological Survey, but on account of the limited funds it is impossible to meet adequately the needs of that service.

The surveys by the General Land Office, by the Mississippi River Commission, by the U. S. Lake Survey, by the Corps of Engineers, by the U. S. Coast and Geodetic Survey, and by the International (Canadian) Boundary Commission are specialized surveys, and while all of these organizations would be in some degree benefited by the early completion of the standard topographic map in the areas in which they operate, still these maps would not obviate the need of the special surveys. Moreover, the results of the work of all of these organizations are used by the U. S. Geological Survey in the preparation of the standard topographic map.

The work of the U. S. Hydrographic Office is entirely outside the continental limits of the United States.

Standard Topographical Maps.—The conference is unanimous in the opinion that to make a topographic map of the United States on a scale sufficiently large to meet all Governmental and private needs and adaptable to all special and unusual purposes is impracticable, due to the extent of territory to be covered and to the imperative need to provide promptly a map on a smaller scale which will fulfill immediate general necessities. However, a standard topographic map of the United States, such as is now being prepared by the U. S. Geological Survey, will be of inestimable value to most of the Government map-making and map-using departments and to the engineering and general public, and over large areas of the United States this map will supply most civil needs. Where it is not sufficient, special surveys will have to be made as occasion demands. It should be clearly borne in mind that revision of the standard topographic map must be made from time to time in order that it may show changes resulting from the development of the country.

The war has made clear the urgency of a map which will supply the general military needs of the United States. Except for certain strategic areas this standard topographic map is most valuable for this purpose and should be completed at the earliest possible moment.

To attain the best results different kinds of topographic surveys in the same territory should, when practicable, be made by the same organization. It is believed that present conditions would be improved by greater concentration of the preparation of special topographic maps in the organization engaged in the construction of the standard topographic map, which has a large trained corps from which specialists can be drawn without serious detriment when needed for the special work for which they have been trained.

In future mapping the use of aircraft will play an important part, and the practical program outlined by the Interdepartmental Committee on Aerial Surveying and adopted at its meeting on May 16, 1919, is endorsed by this conference. This endorsement is based upon the realization that co-operation between the air services of the army and navy and the established map-making agencies is essential to full efficiency and that under the plan of co-operation the problems of transportation in the air must devolve upon the highly specialized air services, while the surveying bureaus control the aerial photography in aid of mapping. The surveyor must be an experienced topographic engineer, whether he operates from the airplane with the camera as his instrument or on the ground with the plane table.

Recommendations of the Conference.—To aid in the co-ordination of effort by the Government agencies making maps and to assist in the production of results more satisfactory to all map-users, it is further recommended:

1. That a permanent Board of Surveys and Maps be appointed to act as an advisory body on all questions relating to surveys and maps; that this board be composed of one member from each of the Government organizations represented at this conference; that the additional duties granted to the United States Geographic Board by the Executive Order of August 10, 1906, be transferred to the proposed Board of Surveys and Maps; and that the Board of Surveys and Maps should hold meetings at stated intervals to which representatives from the map-using public be invited for the purpose of conference and advice.

2. That a central information office be established in one of the Government map-making agencies, preferably in the U. S. Geological Survey, for the purpose of collecting, classifying, and furnishing information concerning all map and survey data available in the several Government organizations and from other sources; that this central office be under the general supervision of the Board of Surveys and Maps and be provided with sufficient funds to enable it to carry out its functions as a convenient and efficient clearing house for the dissemination of information to all branches of the Government and to the map-using and engineering public.

3. That the copyright laws of the United States Government be so amended as to provide that, when presented for copyright, one copy of each map be transmitted to this central information office.

4. That all Government agencies shall comply with requests from the Board of Surveys and Maps for data that may be needed to carry out the purposes for which the board is created.

5. That whenever it may be necessary for agencies other than the U. S. Geological Survey to make field surveys of a nature similar to those upon which the standard topographic map is based, such surveys should conform to the specifications of the standard topographic map.

6. That the U. S. Coast and Geodetic Survey be given general supervision of the final adjustment of all important control data in accordance with specifications approved by the Board of Surveys and Maps.

7. That it is essential to the best interests of the nation that the results of surveys in the form of maps or publications be issued as soon as possible after the field work has been completed.

8. That the practical program outlined by the Interdepartmental Committee on Aerial Surveying and adopted at its meeting on May 6, 1919, be approved.

It is manifest that the public is not fully informed of the work of the map-making agencies of the Government and therefore is not making full use of their publications.

Each of the fourteen agencies of the Government represented at the conference submitted a statement of its map needs and map-making activities. A brief abstract of each of these follows:

Corps of Engineers, U. S. A.—A complete topographic map of the United States on a scale of 1 to 62,500 is needed, together with similar maps of Luzon, P. I., Oahu, T. H., and the Panama Canal Zone; especially is there need of these maps covering the territory within 100 miles of the coasts andd borders of the United States. Detailed topographic maps on a scale of 1 to 20,000 in vicinity of strategic points are desired, kept up to date by frequent revisions. Map-making activities are at present confined principally to the Phillipines, Hawaii and Panama and in the revision of U. S. geological sheets.

Special maps are necessary for practically all Government improvement projects.

U. S. Coast and Geodetic Survey.—This bureau uses effectively all topographic maps of the coast of the United States not already adequately mapped by the bureau, provided the scale and accuracy of such maps are equal to its requirements. The 1:62,500 Geological Survey maps in general meet these requirements for the 1:80,000 coast charts, but not for the larger scale harbor charts. For the latter class of charts topographic surveys must be made in considerably more detail as these charts are constructed on a 1:20,000 or a 1:10,000 scale. Topographic maps should be revised as frequently as practicable to be of use to this bureau.

The topographic surveys by this bureau are made by the usual plane table methods with adequate triangulation control. Relief is shown by contours in accordance with general practice. Control, both horizontal and vertical, is provided by this bureau, and it is not necessary to depend upon other bureaus in making these surveys. It is the practice, however, to make use of all known surveys of sufficient accuracy, in order to avoid duplication, and where such maps are available to confine operations to tying in such maps to our control and supplying any additional data required.

Coast and Geodetic Survey charts are compiled from data obtained from all available sources. The maps of the Corps of Engineers, U. S. Army, and of the Geological Survey are used extensively for this purpose. State, municipal and private surveys of known accuracy are also used. The Bureau of Lighthouses supplies data relative to aids to navigation. Publication and distribution of Coast and Geodetic Survey[2] charts are entirely by its own organization.

This bureau regularly executes primary, and occasionally secondary, control for use of other map-making bureaus and for the use of non-Federal agencies and individuals. In addition it makes special surveys, usually hydrographic, for the use of other bureaus, the cost of which surveys is defrayed either by an appropriation made to this bureau for that particular purpose or by transfer of appropriations from the bureau for which the survey was made.

U. S. Geological Survey.—The internal map of the U. S. Geological Survey may be grouped in two general classes, scientific and economic.

In connection with its purely scientific investigations, standard topographic maps are essential to any comprehensive study of the geology of a region. Economic investigations of the mineral and water resources of the country and the classification of the public lands can not be carried on intelligently without a topographic map. The entire Federal appropriation for topographic surveys would not fully meet these internal needs. Urgent demands from other organizations can not be ignored and, in consequence, topographic mapping of areas under investigation by the Geological Survey is far in arrears.

Most of these internal needs would be met by maps on one of two scales: 1:62,500 for flat or rolling country and 1:125,000 for mountainous areas. A few special needs require maps on a larger scale.

The topographic maps of the Geological Survey are made by its own force of trained topographic engineers from plane table surveys. Results of surveys of other organizations, both Governmental and private, are used whenever available and suitable for the purpose of the map. Credit is always given when such work is used. The control work of the U. S. Coast and Geodetic Survey is always used when available and the topography and hydrography along the coasts is usually taken from the charts of that organization. The river surveys by the Corps of Engineers, U. S. A., and the topographic surveys by the U. S. Reclamation Service are used whenever available.

All the maps of the Geological Survey are printed in its own engraving plant. These are reproduced by photolithography or engraving, depending on the purpose of the map. In addition, a large amount of map printing is done for other Government organizations, including contract work from the Government Printing Office. During the fiscal year ending June 30, 1919, 3,272,430 copies of maps or charts were printed, of which only 712,536 were maps of the Geological Survey.

General Land Office.—The map requirements of the General Land Office are as follows: Township plats showing land subdivisions with measurements, directions, and areas of tracts; maps of public land states showing land survey lines, reservations, and administrative data; general map of the United States showing the sources of acquisition of the land, the civil and public land boundaries, and progress of the land surveys. Special maps are needed for opening Indian reservations, for showing the system of public land surveys, and for showing various internal and departmental activities.

The state maps, as well as the United States map, require revision as the survey of the public lands progress. There is urgent demand for these maps, not only by settlers, but also by Congress, by the Government departments and by the general public.

Topography Branch, Post Office Department. A map made up of atlas sheets or quadrangles, similar to those published by the U. S. Geological Survey on a scale of 1:62,500 of the entire United States would be of great value to this department in the administration of, and in the extension of postal facilities by the Rural Delivery Service.

In the compilation of maps required for use in the postal service, the charts of the U. S. Coast and Geodetic Survey, and the topographic quadrangles of the U. S. Geological Survery are used; when the territory involved is not covered by maps of this character, the best available publications, governmental or private, are consulted. In the orientation of this material, geographic and magnetic positions, determined by the above named surveys, are frequently used.

The maps published by this department number 47 Post Route Maps, including all the states and possessions of the United States, 1,035 Rural Delivery County Maps, and 9,000 Local Center Maps.

Bureau of Soils.—Wherever possible, existing base maps are used. If Geological Survey topographic sheets are available, they are used, with or without corrections, according to the date and accuracy of the map. Where such topographic base is not available, Land Office maps or county maps are used so far as justified. As the work is confined principally to agricultural sections, in a great many instances plane table maps have to be made by the bureau. The records show that approximately 63 per cent of the work is traverse work done by the bureau, 25 per cent is on topographic sheets, and 12 per cent on county and Land Office maps.

U. S. Reclamation Service.—All map-making surveys by the Reclamation Service are for its own use in the construction of irrigation and drainage work and the proper classification of lands. Such use of these maps as is made by other bureaus or the general public is entirely incidental. These surveys may be classified in a general way under four heads: preliminary or reconnaissance surveys, reservoir surveys, surveys for canal location and irrigable land surveys.

The preliminary surveys are made to determine conditions governing water supply, the feasibility of the various possible reservoir and dam site, the area and character of lands available for irrigation and the relative merits of various canal locations. The existence of a good contour map such as that issued by the Geological Survey eliminates a large part of the expense of such investigations.

Reservoir and irrigable land surveys are ordinarily made on scales of 400 or 1,000 ft. to an inch with contour intervals of 2, 5, or 10 ft., depending on the character of the topography and the amount of detail required for design of canal systems and structures.

In making preliminary and canal surveys many miles of transit and level lines are run which are not included in the mapped areas but which would be of assistance to other map-making agencies.

Bureau of Public Roads.—The Bureau of Public Roads is a map-using and not a map-making agency. Considerable use is made of the standard topographic atlas sheets published by the U. S. Geological Survey. The work of the bureau covers the whole country and topographic maps of the entire area of the United States are needed.

The bureau is now engaged on a large Federal Aid road program in co-operation with the several states, and has an urgent need for state road maps. An accurate road map of the United States by states does not exist on which the highway systems can be studied. The topographic atlas sheets are urgently needed for the special uses made of them and because from them the required state road maps can be compiled.

Bureau of Indian Affairs.—The Indian Service is not primarily a map-making institution. It is to a large extent a map user, for it uses wherever possible the basic maps made by other bureaus and agencies in its preliminary studies of irrigation and drainage projects. It is necessary, of course, to make detail surveys in its studies but these are tied in to some of the surveys of others when any such surveys reach within a reasonable distance.

Mississippi River Commission.—The map needs of the Mississippi River Commission are for special types dealing with the hydrography of the river and the topography of a strip varying in width from one-half to three miles on either bank. Its maps require frequent revision due to the rapid changes in the bed of the river.

The surveys are based on a triangulation system extending from the Gulf of Mexico to Lake Itasca and a precise line of levels along the entire length of the river. In the early surveys two arbitrary datum planes were used for elevations which were later referred to mean Gulf level. The North American datum has not been adopted for geographic positions but the triangulation system crosses several U. S. Coast and Geodetic Survey triangulation arcs and the reductions to North American datum could readily be made.

The Mississippi River Commission publishes its own maps and issues pamphlets giving information as to its bench marks and triangulation stations.

U. S. Lake Survey.—The U. S. Lake Survey is engaged in the preparation of navigation charts for the Great Lakes, for the New York State Canals, and for the Lake of the Woods. A standard topographic map in the vicinity of the shores of these waters would be of advantage, but additional shore topography would be ordinarily necessary for the large scale charts.

The charts of the Lake Survey are based on geodetic and hydrographic surveys. Results of the work of other organizations are used whenever available and of sufficient accuracy. All charts are published by its own organization.

Canadian Boundary Commission.—The International (Canadian) Boundary Committee is charged by the treaties of 1903, 1906, 1908 and 1910, between the United States and Great Britain, with the survey and establishment or re-establishment of the International Boundary between the United States and Canada and from the Arctic Ocean to Mt. St. Elias, from Mt. St. Elias to Cape Muzon, and from the Atlantic to the Pacific Ocean, excepting through the Great Lakes and St. Lawrence River and connecting waters.

The maps of the boundary from the Atlantic to the Pacific Oceans are all based on North American datum and the elevations referred to mean sea level, the control having been based on the triangulation stations and level bench marks already established by the U. S. Geological Survey and U. S. Coast and Geodetic Survey. The scales used vary from 1:12,000 to 1:62,500 and the contour intervals from 10 to 100 ft. Detailed maps of small areas were made on scales of from 400 ft. to the inch to 50 ft. to the inch, with 5 ft. contours.

Forest Service.—The general needs of the Forest Service would be met by the present standard map of the U. S. Geological Survey on the scale of 1:62,500, if the location of the section corners of the public land surveys are correctly shown with relation to the topography. Such a map is urgently needed for all National Forest areas and should be extended to a distance of from four to ten miles outside such areas.

U. S. Hydrographic Office.—The work of the U. S. Hydrographic Office is entirely outside the continental limits of the United States and consequently does not require topographic maps of this country.

Original surveys are executed under specifications issued by the Hydrographic Office with funds appropriated to the Bureau of Navigation for ocean and lake surveys. Marine hydrographic surveys are made in foreign ports, and are based on trigonometric coast surveys for the complete development of marine hydrography and such shore topography as is useful for the purposes of navigation.

Suggestions for Consideration by the Proposed Board on Surveys and Maps.—1. That small scale highway maps be prepared in co-operation with state organizations under specifications which will meet the general needs of the Bureau of Public Roads, the several state highway organizations and the automobile-using public.

2. That the use of aircraft photography as an aid in mapping should be considered with a view to expediting the completion of the small scale highway maps and, where practicable, in the work connected with the surveys for the standard topographic map and in its revision.

3. That it is advisable for the U. S. Geological Survey to prepare skeleton base maps, on suitable scales for the use of those agencies which require skeleton maps on which to show results of industrial or scientific investigations.

4. That suitable graphical scales in English and metric units be printed on all maps prepared for general use.

5. That there should be printed on the margin of all standard topographic maps a diagram of the control on which the map is based, together with reference to the published data, in order to show the basic control available for special surveys.

6. That the following specifications for surveys and maps be adopted in so far as practicable by all map-making agencies of the Federal Government and that every effort be made to have the same specifications adopted by the non-Federal agencies in order that survey and map data may be suitable for incorporation into the standard topographic map of the United States:

A. North American datum for geographic positions and mean sea level for elevation should be used where practicable.

B. Permanent monuments or marks, properly referenced, for both horizontal and vertical control should be standardized and established at frequent intervals, and descriptions of the character and location of the same systematically recorded and published.

C. Horizontal and vertical control should be executed with an accuracy at least equal to that required for the control of the standard topographic maps.

D. Drainage, relief, culture, boundaries of all civil divisions, reservations, grants, and lines of public land surveys, when shown, should be located with at least the same accuracy as on present standard topographic maps of the U. S. Geological Survey.

E. There should appear on all maps or plats of surveys:

(a) Descriptive title, giving location by state, county, or other limits.

(b) Name of the organization responsible and name of the surveyors and draftsmen executing the work.

(c) Fractional scale and graphical scales in feet or yards, meters, and miles.

(d) True meridian, magnetic meridian, and variation with date and rate of change.

(e) Contour interval if contoured.

(f) Horizontal and vertical datums.

(g) Date of survey or date of compilation with source of information.

(h) The name of projection used or, if without projection, the latitude and longitude of at least one point, as accurately as practicable.

(i) The location of all permanent marks on which the survey is based.

(j) An explanation of any symbol used which is not generally understood.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Forms.—Blaw-Knox Co., Pittsburgh, Pa. 28 page bulletin illustrating and describing the use of Blaw forms for light walls and foundations.

Industrial Housing.—Unit Construction Co., St. Louis, Mo. 16 page bulletin with map describing the industrial housing development of the Youngstown Sneet and Tube Co.

Building Products.—H. H. Robertson Co., Pittsburgh, Pa. Six well gotten up and interesting bulletins on Robertson products. The bulletins contain many half-tone illustrations and detail drawings, as well as useful tables for estimating. Bulletin No. 61 is devoted to glazing construction. Bulletin No. 62 covers the use of Robertson process metal in industrial building construction, Bulletin No. 63 illustrates and describes fireproof plans for structural steel buildings. Bulletin No. 64 is devoted to gypsum in precast roof construction; this bulletin also contains an article by Prof. Charles L. Norton on the heat insulation value of Robertson gypsum roofs. Bulletin No. 65 covers ventilation. The other bulletin gives a general description of Robertson process products in metal, gypsum and asphalt.

Industrial Notes

The Richardson-Phoenix Co., lubrication engineers and manufacturers, Milwaukee, Wis., has reopened its Philadelphia, Pa., offices, which were temporarily closed during the war. The offices are located in the Bailey Bldg. with Geo. F. Fenno as district manager.

F. W. Ruggles, president of the Republic Motor Truck Co., Inc., of Alma, Mich., formally announces that he has, in conjunction with John N. Willys and W. J. Baxter of New York City, acquired control of the Republic Motor Truck Co., Inc., and the Torbensen Axle Co. of Cleveland, O. The Willys-Overland Co. of Toledo, O., is no in no way connected with the transaction, which was a purely personal investment by Mr. Ruggles, John H. Willys and W. J. Baxter. It is announced that the original administrative policies of the Republic Motor Truck Co. will in large measure be continued.

W. H. Cornwell, State Senator, Chicago; State Senator Harold Kessinger, Aurora; Representative Horace McDavid, Decatur; Representative G. A. Dahlberg, Chicago; Robert Knight and Charles Hommond, business men of Chicago, and Andrew Lanquist, Chicago, a contractor, have been appointed members of a State Housing Commission by Gov. Lowden of Illinois. The commission is authorized to prepare a state housing code, a building code, and a zoning bill, to be presented at the next session of the State Legislature.

Road and Street Monthly Issue

ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging (c) Quarries and Pits
(b) Rivers and Canals (d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings (c) Harbor Structures
(b) Bridges (d) Miscellaneous Structures
(e) Properties of Materials

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The Greatest Economic Blunder of All Times

At the head of the procession of mastodonic economic mistakes we expect to see historians place the one that has resulted in greatly raising the general level of prices throughout the world during the past five years. Nearly all the industrial upheaval and labor unrest of Europe and America is traceable to the inflation of the currency. Had all statesmen known certain principles of political economy, the world war would have been conducted without any appreciable increase in the supply of money in any country. But in Europe the total amount of money has been tripled, and in America it has been increased more than 50 per cent. The result has been economic trouble heaped high upon economic trouble to an extent that the world has never witnessed before.

Although the world has never before had such widespread and enormous economic disturbance, there has been similar trouble following every great war of modern times, and for precisely the same reason—the inflation of the currency.

About 140 years ago Adam Smith wrote his "Wealth of Nations," a book that profoundly affected the views of many political leaders of Great Britain and of students of political economy in all countries. He made it clear that international trade is, in the final analysis, merely the barter of goods for goods; hence that a continuous "balance of trade" in favor of one country is not only impossible but undesirable unless the citizens of that country are spending or investing the "balance" in foreign countries. In short, he showed the fallacy of the old "mercantile theory of foreign trade" in which a nation regards itself as if it were an individual who grows wealthy in proportion as he accumulates money.

The wealth of a nation, as Adam Smith made clear, may be computed in terms of money, but it consists not in the money itself. It consists almost entirely of the raw materials, the land, the buildings, the 'plant" and the stock of goods on hand. The real wealth of the United States now exceeds 300 billion dollars, of which about 3 billions, or 1 per cent, is gold. Paper money, bank deposits in excess of gold and silver, stocks, bonds, mortgages and notes are not national wealth; they are merely instruments for apportioning national wealth among individuals. All this and more was made clear beyond refutation by Adam Smith. Yet behold the political and industrial mess that nearly every nation on earth has made of things during the past five years, through failure to apply the principle that Adam Smith established, nearly a century and a half ago!

Behold also the struggles of politicians everywhere to readjust industry without going to the original cause of its trouble—currency inflation. Behold this and marvel, for here you see men who should know the principles of political economy vainly

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

striving to solve present problems of high prices without applying the fundamental principle that Adam Smith first expounded during the very year that the Declaration of Independence was signed in Philadelphia.

Had Adam Smith erred in his analysis, and in his conclusions as to the relation of money to national wealth, his mistake would long ago have been bared and his name forgotten. But every writer of a treatise on political economy has subscribed to the keenness of Adam Smith's perception and to the soundness of his conclusions that the real wealth of nations consists but slightly of money, and that international trade is essentially barter of goods for goods.

Granted, you may say, but what has this to do with financing a war? This: That it is an economic mistake suddenly to increase greatly the currency and bank deposits in any country, be the exigencies what they may. Doubling the money or the equivalent of money (e. g., bank deposits) doubles the average price of things, but adds nothing to national wealth. If every citizen were to have his cash, bank deposits, stocks, bonds, wages, etc., doubled in dollars, at the same moment that the total supply of money were doubled, no economic loss would result and no economic gain would result, except as international trade might be affected. But there is no practical way of thus distributing uniformly and at once any increase in currency; hence there is certain to be great economic disturbance where great increases in currency occur. Moreover, such disturbances are of long duration and far reaching. Finally, when they are all settled, at least after a fashion, the nation as a whole has no more wealth or income than it had before the increase in the currency, and during the period of disturbance has failed to add the annual normal increment of wealth.

Had this fact been clearly seen and acted upon, no government would have permitted an increase in currency during the war. What is more, no government would have permitted any great increase in bank deposits, for they are the equivalent of money in purchasing power. To have held the total purchasing power to about a constant level would have been the aim of statesmen in every nation engaged in the war. To attain this aim, each government would have conscripted all workers and all industries, dictating to everyone the part that he would have to play.

Is this an untried plan? No. It is precisely what the chiefs of savage tribes have always done. With mind unconfused by the presence of money, and unhampered by intertribal commerce, the chief of a savage tribe sees clearly that he must specify what each individual must do to win the war. Some of the hunters must be called in to become warriors. All the makers of amulets and finery must become manufacturers of bows and arrows. All the idlers must be given work or fighting to do.

Accustomed as civilized men have been to the use of money and evidences of property ownership as devices with which to conduct business, their leaders have been blinded to the possibility of conducting the business of war without adding to the number of these tokens of wealth. Or if not blinded, they have lacked the courage to do the thing that a savage chieftain would do. So now the world is harvesting the crop of nettles and stinkweed that political leaders sowed in every nation during the war. The seed that they sowed was paper money, bonds and other credit securing devices.

In America we waxed happy over our huge monthly balances of trade throughout the war. We grew eloquent over the millions of gold that Europe shipped to us. And now that we have their promises to pay and much of their gold, are we a whit wealthier? Not one whit. The billion dollars of gold that we drew from Europe was added to the two billions that we already had, and coincidently our bank deposits rose from the 18 billion level to the 27 billion level. Up went the general price level to the same extent and more. Those individuals that gained by the change were offset by those that lost, and that was the main cause of labor wars, of extravagance, and of all those itinerant troupes of industrial troubles that are now barnstorming every city and village in America.

America would be better off were it to cancel the nine billion dollar debt that Europe owes and ship back the billion dollars of gold. What will they pay their debt with? Gold? We don't want it. We have 50 per cent more than we need now. Goods? We don't want them, for by as much as we shall import by that much we shall throw Americans out of work. Imports and exports should practically balance every year. Let there pile up a large "balance of trade" in our favor, and there will result a disorganization of industry later on; for if much gold be imported to square the account, the general level of prices will rise with resultant disturbance, while if the debtor nation once falls far behind in paying with goods, its efforts to catch up by supernormal production will throw men out of work in the creditor nation.

America should not only cancel the debt of England, France and Italy to us, but should "grubstake" those peoples that are starving. Beyond that, they should be required to "pay as they go" and pay with goods. If they must have food, then let us divert some of our producers from the factories to the farms and railways. Let those that we thus support with food repay with manufactured articles.

Either this should be done, or, if America is capable of producing more food and manufactured products than we can consume, then let the demands of labor unions for shorter hours be granted. The only alternative to this last solution of the problem is to change the present demand for things, preferably diverting it to a demand for better houses, better roads, better transportation facilities, better education and those numberless things that accelerate human progress and add to lasting happiness.

Huxley's Conception of a Liberal Education

Last week we commented on the "objects of a college education" as specified by Woodrow Wilson and A. Lawrence Lowell. By way of contrast we now quote from the great English scientist, Huxley:

> That man, I think, has had a liberal education who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that as a mechanism it is capable of; whose intellect is a clear, cold, logic engine, with all its parts of equal working strength, and in smooth working order; ready like a steam engine to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of Nature and the laws of her operations; who, no stunted ascetic, is full of life and power, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of Nature or of art, to hate all vileness, and to respect others as himself. Such a one and no other, I conceive, has had a liberal education.

Admirably as Huxley has phrased his specification, and broad as he has made its scope, it lacks a necessary element—the same element that we found lacking in the educational specifications of Mr. Wilson and Mr. Lowell, namely a training that begets a thirst for useful knowledge and an ability to apply it. Herbert Spencer in his admirable little book on education also fails to mention this essential factor.

William James, the American psychologist lays great emphasis upon the development of good habits of mind, but if we remember correctly, even he does not specify the desirability of developing the habit of searching for useful information. However, the editor acknowledges his indebtedness to James for the idea that the primary object of education is the development of habits, physical and mental. If this is a correct conception of what should be the general aim of the educator, it follows that special effort should be made to cultivate the habit of searching for information.

To the absence of this habit in most men may be attributed the relatively slow progress of industry, business and applied science. The leaders in these various lines of mental activity are fully ten years ahead of the "crowd," and they remain far in advance, not because they keep secret their knowledge and methods but because the "crowd" does not take the trouble to study what is in print.

If you are not receiving an adequate income, sit down with yourself tonight and ask why. Do not begin by blaming the world and its ways. Do not end by blaming yourself. Perhaps you have not been trained to search systematically for data to use in solving your problem of securing an adequate income. Possibly you have never been habituated to regard your troubles not as if they are evils to be cursed but as problems to be solved. You are in the midst of many forces, and you yourself are one of the forces that determine whither you shall go. Study yourself, and to do so study psychology. Study the forces that surround you. Habituate yourself to study everything that affects your welfare. Join a Chautauqua society, a debating club, any thing that will tend to make you search for knowledge. Read Smile's "Self Help" for inspiration. Read "How to Study" by Prof. G. F. Swain of the civil engineering department of Harvard.

Cowardly State Legislators Refuse to Raise Highway Salaries

In several states the legislatures have recently failed to provide for adequate increases in the salaries of state highway employes. Why? Merely because the average legislator is "scared of everything," as the Chicago Tribune puts it.

In order to avoid incurring the displeasure of farmers and other taxpayers, by raising taxes, state legislators prefer to pay inadequate salaries to state employes. One of the great defects of our present representative system of government is that it breeds cowardice. Nor do we see how this defect can ever be remedied until radical changes are made in our form of representative government.

The city manager form of municipal government, which was described by Mr. F. W. Gruenberg in our issue of Nov. 26, has served to eliminate boards of aldermen and city councils, supplanting them by a city commission to whom the city manager reports. It is feasible, and we believe desirable, similarly to displace state legislators by a state commission consisting of about nine members. This commission should appoint the governor who should be required to pass a civil service examination. The governor should appoint the heads of departments.

Even if no further change were made in the present system of state government than that just suggested, there would result less political log rolling than now exists, and much of the present legislative cowardice would disappear. Therefore engineering societies should become leaders in the movement to remodel our system of state government.

Mr. Gruenberg, director of the bureau of municipal research of Philadelphia, is not an engineer, yet in the paper that appeared in our last week's issue he said:

> The vast majority of the 125 city managers in this country today are civil engineers. While I do not know offhand the exact figures, I am safe in saying that it is exceptional to find an important city manager who is not an engineer of some kind; here and there a mechanical, electrical or chemical engineer, but most of them are civil engineers. * * * The public service engineer of the future will have to be a many-faceted man. He will have to be a well-rounded technical man if he is to be a city manager, so that he can know the meaning of his problems. He will have to be a man who will know what government stands as a social force, so that he will be a leader instead of a follower in public service. * * * The thing resolves itself down to this: With the increasing complexity of government a trained public service is indispensable. If democracy is to succeed, the old tradition of putting the politician in the technical administrative post must soon cease, and democracy must look to the professional public servant to take up the burden Nowhere is there thus far developed a nucleus for such a professional group in America to such an extent as in your profession, and I would plead with you, therefore, not to miss this opportunity of twofold attractiveness; first, to serve our communities in posts of unique importance and responsibility, and, second, to afford professional careers comparable with the best in the other professions in the opportunities offered for material reward and in the esteem of fellow citizens.

The A. A. E. Drive for 10,000 New Members

The largest sales organization that ever sold an engineering commodity went into action last Monday. The commodity is memberships in the American Association of Engineers, and the salesmen are the present 8,900 members. The 59 chapters and the 35 clubs of the Association are the branch sales offices. This briefly sums up the organization that is carrying out a drive that has for its object the securing of 10,000 new members for the A. A. E. in the two weeks, Dec. 1 to Dec. 13.

The keynote of the drive is sounded as follows by Prof. F. H. Newell, President of the Association:

"What will engineers pay to improve their status? I have visited many of the centers of population during 1919 from the Atlantic to the Pacific Coast, meeting engineers of all kinds, civil, mechanical, electrical, mining and chemical, socially and in their offices, obtaining a broad view of the situation.

"It is apparent that while the older technical societies are needed and are performing valuable functions and should be maintained to continue these functions, yet they cannot and do not have the money, experience and attitude to carry on economic or humanitarian work. For efficiency there must be a larger, more inclusive society taking in all professional engineers and devoting its entire funds and energies to the good of its members. Such an organization is the American Association of Engineers. This is answering the question as to what engineers will pay to improve their status."

Started in 1915, the American Association of Engineers, on Nov. 21, 1919 had 8,906 members. What is the reason for this phenominal growth? It will be found, we believe, in the objects of the Association: "To raise the standard of ethics of the engineering profession and to promote the economic and social welfare of engineers."

The Engineer and the Library

To the Editor: In the editorial "Why Do Most Practicing Engineers Study So Little?" in your Oct. 29 issue, you point out that the average daily attendance at the consolidated engineering library in New York City is only 78. Perhaps the practicing engineer has a specialized library of his own, so that the public library attendance is not a true index of his study time. I study 5 or 6 hours each week without going to the good technical library (Goodwyn Institute library) in this city. I only go to the library for side lines, or information on engineering subjects other than those in which I am directly interested.

C. E. G. NEARER,
Memphis, Tenn. Structural Engineer.

[Mr. Nearer suggests that the reason why engineering society libraries are so poorly patronized may possibly be found in the fact that most practicing engineers have their own library. It is doubtless true that there are many engineers who have their own books and periodicals and study them as Mr. Nearer does. But if this were the general rule the sales of technical books would be far larger than they are; also the subscription lists of all technical journals would be much greater than they are.—Editor.]

Sub-Grade for Rigid Pavements

To the Editor: I should like to see more discussion in the current engineering magazine relative to the construction of the sub-grade for rigid pavements. There has been an indefinite amount of discussion and analysis about the proper method for designing and constructing the surface of the different types, but the sub-grade, which is common to all of the types and the most important feature of pavements, has not received the attention which it should. On most of the ordinary types of surfacing, the design and specifications are fairly understood. At the same time, I would not want anyone to understand me to mean that there is not need of more improvement in this line.

The life of any pavement is dependable upon the stability of the sub-grade. If this be true, the most important element, therefore, is proper construction to gain this stability. Reduction of water content and segregation of excavated materials are the two elemental features to gain this end. There are many ways to reduce the water content of the sub-grade. In the first place, I would suggest that a soil survey and analysis be taken, as some soils retain water for a longer period than others.

As a usual thing in making this survey, the different kinds and conditions of, say, clay for instance, are not given enough consideration. The proper drainage of clay is dependable upon the sand and gravel content in the clay. Some clays have enough sand not to hinder a great deal the rapid and efficient drainage, but others must have artificial drainage. Therefore, sand and gravel are the main elements in the soils that govern the necessity of artificial drainage.

Since the drainage to be of any effect must take place quickly, there are many things that must be taken into consideration. Tile drains should be constructed by the "herringbone" method throughout the entire length of the road. The system should have lamp holes, catch basins, deep ditches and gravel back fills, and the tile should be laid to an absolute grade with a minimum of 0.2 per cent gradient. No grade should be less than 0.2 per cent and the embankments should be high and uniform.

The knowledge which should be derived from experiments with soils of different characters in order to determine the time-gallon drainage of them would unquestionably be of great value. Knowing the facts of these experiments, certain other facts could be deduced which would show what could be done in these soils as to drainage. Possibly some reader already has some data along this line.

In building the sub-grade a great deal of attention should be placed upon the proper segregation of the various soils to be excavated; i. e., the top soil, which is usually easier to drain than the sub-soil, should be in the center and the lower part of the embankment, while the sub-soil should be placed on the top as surface. If sand or gravel occurs in the cut, it should be placed in layers in the sub-soil so as to insure good drainage of the embankment side. Of course, this matter of the sub-grade was thoroughly discussed during the railroad construction period, but on highway construction we have a different type of traffic to sustain, and the surfacing is in one piece instead of a multiple of parts. So, different methods of construction are required.

Another thing which I think is very bad practice, is the placing of the surfacing material upon newly or partially new constructed sub-grades. Pavements which are laid upon newly constructed sub-grades, especially where the old roadbed forms a core of the new, develop longitudinal cracks due to unequal settlement. The time limit to allow for total settlement is a matter of much speculation, but I believe that a year with constant maintenance to keep the sub-grade to grade is time enough. O. C. WHITE,

Highway Engineer, Mower County, Minnesota.

The Economic Limits of Motor Truck Weights

To the Editor. The constructive criticism requested in the discussion of Mr. Barnett's contribution on "The Economic Limits of Motor Truck Weights" is quite impossible, unless it is admitted that convincing destructive criticism is, in effect, constructive, whether it be advanced by a legal or an engineering type of mind, and for the following reasons:

The author's method of reasoning generally results in an algebraic expression in which one or more unknown constants are introduced which may later be determined by experiment, be modified at the will of the author, or dropped entirely when inconvenient in the pursuit of a result.

The symbols and equations so freely used appear imposing to the layman unfamiliar with algebra and are confusing even to the engineer who uses algebra and the calculus, because so many indefinite symbols are introduced and frequently dropped in the discard with such apologies as, "From this we conclude that for practical purposes" . . . or "a discussion of this detail is reserved for a future paper" . . ., etc.

As an example of the indiscretions or license taken note Case I and Case II on the thickness of pavement. Case I covers a type of pavement in which the base material is slightly cemented or bound together by the interlocking of angular particles so that internal friction is highly developed but it is devoid of tensile strength and incapable of resisting bending stresses. Case II covers a type which is thoroughly cemented together, well adapted to resist compression and shearing and having a fair degree of tensile strength, so that it is fairly capable of resisting bending stresses.

The development of the expression for the value of d in Case I is not very objectionable, although r_1 represents the radius of a circular upper load area while the actual load area is neither a circle or a point and R_1 is purely a guess dependent on the value assumed for α.

The determination of the value for d in Case II starts out with the statement that the "reaction at any point in the loaded area at the base of slab will be proportional to the depression of the subgrade at that point"; this is not true, but the writer will pass on with the statement admitted for the purpose of this argument.

With the relation assumed the depression of the subgrade would be the measure of the deflection of the slab and Pa must therefore vary inversely as the cube of the depth d of the slab, while the wheel load or weight w which the slab may support will vary directly as the square of the depth d.

The equation with W and Pa only under the radical sign and d only to complete the equation, Pa varying as the cube and W varying as the square of the depth d, is entirely irrational: it does not represent the case nor is it even approximately true "for practical purposes."

This may be illustrated in another manner, viz.: Assume a case of a square slab whose horizontal dimensions are β and thickness or depth is d, and let ρ represent the outer fibre stress due to flexure; the moment of resistance will be $M_R =$ pbd 2/6 and the bending moment will be $M_B =$ Wb/8 = PaB 3/8. Equating and reducing

$$d^2 = .75W/\rho = .75\ Pa\ B^2/p.$$

It will be noted in these equations that when W appears, Pa disappears, and the reverse, a fact which is fundamental in the simplest forms of all moment equations when one quantity is a direct fraction of the other.

If an equation based on the deflection of the slab should be written it would take the form,

$$d = \text{a constant } \sqrt[3]{B^5} \text{ or constant } B \cdot \sqrt{w/Pa}.$$

The formula $d = \sqrt{w/APa}$ is a fairly good approximate expression for Case I; none of the equations can be reasonably applied to Case II and no amount of "hocus-pokus" or imagination will produce a simple equation such as $d = b\sqrt{w}$ that can be even approximately true for both cases.

In the article under discussion on page 375 of Engineering and Contracting, Oct. 1, 1919, it apears that "for the present the intensity of pressure will be considered uniform over the load area at the base of the pavement"; it is with that meaning the value Pa has been used in all the equations. Giving it another name, "the bearing capacity of the subgrade which is a function of the physical properties of the soil," does not affect the analysis in any respect.

The entire problem may be inverted, the wheel load may be replaced with a column supporting a floor slab and the pressure on the subgrade may be replaced with a load on the floor slab without vitiating the analyses in any particular.

If Mr. Barnett will look closely at the equations $d^2 = .6366\ w/f$ and $d = .798\sqrt{w/f}$, on page 523 of Eng. & Cont., Nov. 5, 1919, he will find that "R, upon which the unit pressure (not bearing capacity of the soil) depends," is eliminated in the equations for the value of d.

Of the two fundamental facts stated on page 524 the first is conceded to be true and the second is not true for cases within the limits of motor truck loads and subgrade conditions ordinarily required in the construction of slab type concrete pavements.

In the original paper upon the subject, Engineering and Contracting, February 11, 1914, the title indicates that the equations apply to "a slab supported on earth or other yielding foundation" and the limits within which the equations are true are stated thus: "In other words, the solution is based upon deflection without rupture and compression without lateral flow."

The analysis does not attempt to cover cases where the subgrade may be so hard that a slab would not be required, or so soft that there would be a lateral flow of material when loaded, nor would it apply in case cavities are formed under the slab by settlement or disintegration, or in severe cases of saturation or mud.

With a disagreement clearly established on the first sections, covering the largest item of cost of pavement the writer is not convinced that a discussion of the remainder of the article would be economic.

Chicago, Ill. J. W. PEARL.

Engineer Post of American Legion Organized in Chicago

Castle Post of the American Legion held its election of officers Nov. 25, 1919, at a meeting in the rooms of the Western Society of Engineers. This post is composed of engineers of all schools and from many branches of the Engineering Corps of the Army, and in this respect is unique in that it has not based its membership on any locality or from any organization but has undertaken to bring together in one post the men who served from Chicago in the many phases of the engineering problems of the war and who, by reason of their technical training and their military experience, are going to be active factors in the great question of our military preparedness. A cordial invitation is extended to all engineer service men in Chicago and vicinity to join this post. Applications may be filed with the secretary of the Western Society of Engineers, 1735 Monadnock Block, Chicago. The officers of the post, all of Chicago, are: Commander, R. I. Randolph, 1133, 208 S. La Salle street; Vice-commander, Myron B. Reynolds, City Hall; Adjutant, Walter A. Wade, 1400 First National Bank; Finance Officer, Eugene C. Heron, 914, 910 S. Michigan avenue; Directors: C. Vandeventer, First National Bank Building; Arthur R. Lord, 6 N. Clark street.

Capacity Load and Ruling Grade in Highway Transportation

By R. C. BARNETT.
Economic Engineer, Kansas City, Mo.

In order to produce economical highway transportation, the motor truck or the tractor should haul as nearly as possible its capacity load. This capacity load which any truck or tractor, working alone or in combination with trailers, can haul over a given stretch of highway is limited by the steepest, or "ruling," grade on the highway. The effect of this ruling grade is to reduce the remaining part of the selected highway to its own limitations. The momentum of the moving mass cannot be utilized to any considerable extent for negotiating an adverse grade as is done in railway operation. The hauling conditions on a road are very different from those on a railway. The tractive resistance of the highway is much greater than that of the steel rails and consequently the energy of the moving load is absorbed thereby to a large extent. Again the interference of the cross traffic as well as that of approaching vehicles compels a slowing down of the speed of the truck and prevents coasting. The highway does not afford any particular vehicle a free, open head-way that a railway provides for the movement of trains. For these reasons, momentum grades are not to be considered in highway work. Therefore, on the same principle that a chain is no stronger than its weakest link, a highway, as a factor in transportation, is no more effective than its ruling grade. This obvious truth is not sufficiently appreciated by many persons connected with highway development. For this reason it is worth while to discuss the relation between capacity load and grade. The following elementary considerations are involved:

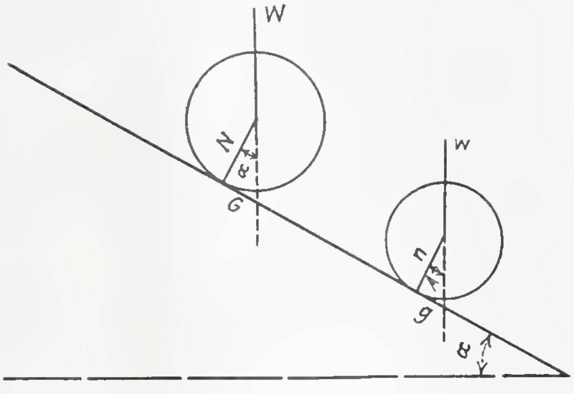

Fig. 1.

Let W = weight on drivers of truck or tractor.
w = total weight on wheels of trailers.
N = normal pressure of tractor or truck drivers on pavement.
n = normal pressure of trailers.
α = angle of slope.
G = component of tractor or truck weight parallel to slope.
g = component of trailer weight parallel to slope.
f = coefficient of sliding friction between tires and road surface.
t = unit tractive resistance of pavement.
T = total tractive resistance.
P' = force available for pushing truck or tractor up the grade.
P = drawbar pull available for hauling trailers.
F = force required to move trailers up grade.
K = "kick-back," or push, of tires on the pavement at point of drivers slipping.

First consider a motor truck operating alone and having two-thirds of its total load on the drivers at the rear axle.

With a sufficiently powerful engine and proper gear ratio to slip the drivers, the kick-back will approach, but will not exceed, the product of the normal pressure by the co-efficient of sliding friction, or

$$K = fN = fW\cos\alpha$$

Some of this kick-back is neutralized by the tractive resistance which the road surface offers to both front and rear wheels. The tractive resistance for the rear wheels is equal to tN, while that for the front wheels is one-half as much. Then the total tractive resistance for the truck or tractor is

$$T = tN + 0.5tN = 1.5tN = 1.5tW\cos\alpha$$

The force available for pushing the load up the hill is

$$P' = K \quad T = fW\cos\alpha - 1.5tW\cos\alpha$$
$$= W(f - 1.5t)\cos\alpha$$

This function is represented by the full line in Fig. 2.

The force tending to move the load down grade is the component of the load parallel to the slope. For the rear wheels this is G and for the front wheels 0.5G, but

$$G = W\sin\alpha$$

then $$1.5G = 1.5W\sin\alpha$$

This is shown in Fig. 2 by the dotted line

P' must equal or exceed 1.5G in order that the load may move up the grade. From Fig. 2 it is seen that P' does exceed 1.5G for all grades under 24 per cent. The excess is shown by the intercept between the two curves. This intercept measures the drawbar pull available for hauling trailers.

Therefore $$P = P' - 1.5G$$
$$= W(f - 1.5t)\cos\alpha - 1.5W\sin\alpha$$

Second: Consider a motor truck or tractor with trailers.

The resistance offered by the trailer load is the parallel component, g, and the tractive resistance, T.

but $$g = w\sin\alpha$$
and $$T = two\cos\alpha$$
so $$F = g + T$$
$$= w\sin\alpha + tw\cos\alpha$$

The trailer load may be increased until the resistance it offers equals the available drawbar pull, or until F = P, then

$$w\sin\alpha + tw\cos\alpha = W(f - 1.5t)\cos\alpha - 1.5W\sin\alpha$$

Dividing this equation through by cos α, we have

$$w\tan\alpha + tw = W(f - 1.5t) - 1.5W\tan\alpha$$

Tan α is the rate of grade expressed as a decimal.

Solving for w, the trailer load, we obtain

$$W = \frac{W(f - 1.5t - 1.5\tan\alpha)}{t + \tan\alpha}$$

When the road is level, tan α reduces to zero and

$$w = \frac{W(f - 1.5t)}{t}$$

Values for f have not been so well determined as for t. For

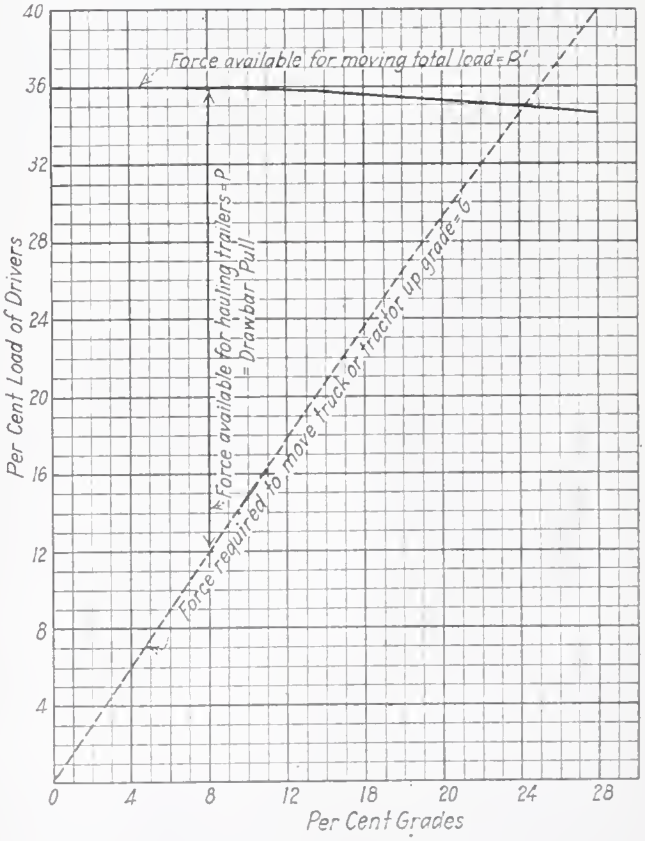

Fig. 2—Drawbar Pull.

$P = W(f - 1.5t)\cos\alpha - 1.5W\sin\alpha$.
Average value of f taken as 0.4.
Average value of t taken as 0.03.

the present a range of 0.4 to 0.6 is used for f, while t is based upon the experiments and tests of Prof. J. B. Davidson of California.

Figure 3 shows the effect of different grades in reducing the hauling capacity of trucks. It is important to note that the trailer load falls off more rapidly for the hard, smooth type of pavement than it does for the other kind. In order to preserve the advantage which the hard, smooth pavement offers on a level grade, the ruling grade must be made considerably less than that allowed on an inferior road surface. A concrete example will best make this clear.

Assume a roadway with a ruling grade of 5 per cent and a truck or tractor that can pull a trailer load of 30,000 lb. on a level gravel pavement. As shown in Fig. 3, the trailer load would be reduced by this ruling grade to about 34.6 per cent of that on the level road, or to 10,400 lb. Now assume that the gravel pavement is to be replaced with a first class one such as brick or concrete, then the same truck could pull on a level grade about 2.9 times what it could on the level gravel road, or 87,000 lb. If the ruling grade is allowed to remain 5 per cent, the trailer load would then be 17.5 per cent of the load on the level, or 15,200 lb. This is only 1.46 times that which could be hauled over the 5 per cent gravel grade.

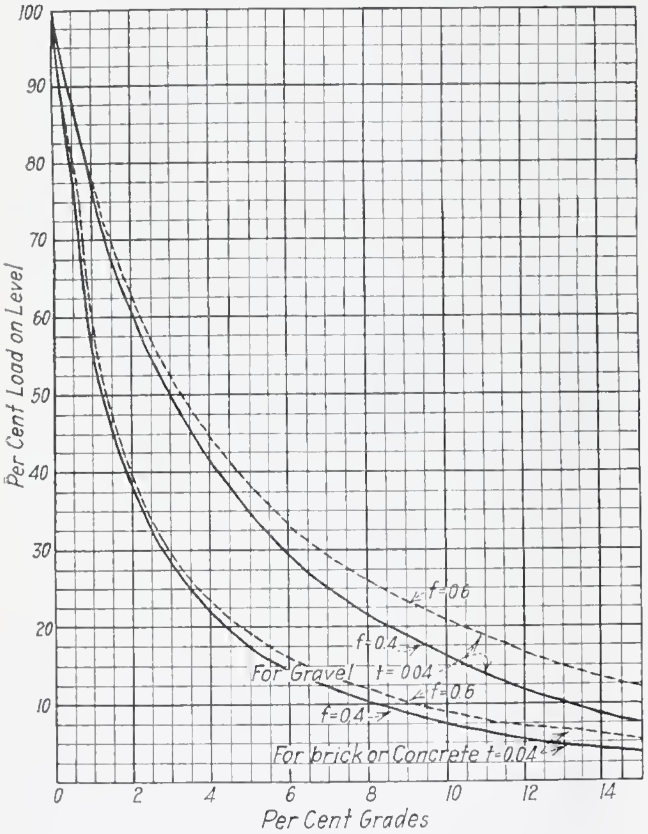

Fig. 3.—Effect of Grades in Reduction of Trailer Loads.

$$w = \frac{W = (f - 1.5t - 1.5 \tan a)}{t + \tan a}$$

in which

w = trailer load.
W = load on truck drivers.
f = coefficient of sliding friction of tire on pavement.
t = unit tractive resistance.
a = angle of slope.

From this it is seen how much more important it becomes to reduce ruling grades for high class, smooth pavements than for the other type. In order for the hard, smooth pavement to retain a uniform advantage over the gravel pavement, the ruling grade would have to be reduced until the truck or tractor could pull 2.9 times the load that it could on the 5 per cent gravel, or 30,160 lb. As 30,160 is about 34.6 per cent of the 87,000 lb. load which could be hauled on the level brick or concrete surface, we look in the chart for the corresponding grade and find it to be 2.3 per cent. This means that the ruling grade of 5 per cent which was allowed on the gravel pavement must be reduced to 2.3 per cent for the hard, smooth surface in order to maintain the advantage that the latter has over gravel in lowering the cost of transportation. This fact has not yet had the attention that its importance deserves.

Labor Cost of Paving Alleys With Concrete

The following data were obtained in paving four alleys at University City, Mo., in 1917 and 1919:

Alleys Nos. 1 and 2 were constructed in June and July, 1917. The pavement was one-course concrete 7 in. thick, 1:2½:5 mix. A gasoline mixer mixing 7½ cu. ft. at a batch, was used and the concrete was spouted onto the finished subgrade, spread and leveled by hand and then struck off with a template. The surface was then worked with a long handled heavy wooden float, and finished by hand with a wooden hand float from a bridge. Expansion joints of elastite were placed every 33 ft. (without iron armor edge protectors). The concrete was cured with 2 in. of clay kept wet for seven days and removed at the end of 14 days.

The labor costs were as follows:

ALLEY NO. 1.
15 ft. wide, 1.446.3 sq. yd.

	Per sq. yd.
Foreman, 50½ hr. at 50 ct.	$0.01737
Finisher, 52 hr. at 50 ct.	.01798
Engineer, 55¼ hr. at 40 ct.	.01528
Waterboy, 50¼ hr. at 12½ ct.	.00434
Labor, 511½ hr. at 30 ct.	.10610
Total labor cost	$0.16107

ALLEY NO. 2.
15 ft. wide, 1,444.5 sq. yd.

	Per sq. yd.
Foreman, 57 hr. at 50 ct.	$0.01973
Finisher, 57 hr. at 50 ct.	.01973
Engineer, 57 hr. at 40 ct.	.01578
Waterboy, 47 hr. at 12½ ct.	.00407
Labor, 509 hr. at 30 ct.	.10571
Total labor cost	$0.1650

Alleys Nos. 3 and 4 were paved in July and August, 1919, with 1-course concrete, 6 in. thick, 1:2½:5 mix. A steam mixer was used, taking 10 cu. ft. to a batch. The concrete was spouted onto the finished subgrade, spread and leveled by hand, and struck off with a template, then finished with a macon roller and belted. Expansion joints of elastite were inserted every 33 ft. (without armor edge protectors). The concrete was cured with 2 in. of clay kept wet for seven days, and removed at the end of 14 days. Labor costs were as follows; they do not include grading or shaping subgrade.

ALLEY NO. 3.
15 ft. wide, 1,525 sq. yd.

	Per sq. yd.
Foremen (2), 174 hr. at 55½ ct.	$0.0633
Finisher, 87 hr. at 66 3/5 ct.	.0380
Finisher, 87 hr. at 44 2/5 ct.	.0253
Engineer, 82 hr. at 50 ct.	.0270
Labor, 637 hr. at 36 ct.	.1498
Labor, 251 hr. at 40 ct.	.0660
Total labor cost	$0.3694

ALLEY NO. 4.
15 ft. wide, 1,525 sq. yd.

	Per sq. yd.
Foremen (2), 164 hr. at 55½ ct.	$0.0599
Finisher, 82 hr. at 66 3/5 ct.	.0630
Finisher, 82 hr. at 44 2/5 ct.	.0240
Engineer, 91 hr. at 50 ct.	.0300
Labor, 405 hr. at 46 ct.	.1064
Labor, 125 hr. at 40 ct.	.0328
Labor, 289 hr. at 36 ct.	.0684
Total labor cost	$0.3576

Alleys 1 and 2 were completed in one week each. The contractor had a full crew on the job all the time and had his material well placed, and lost practically no time. Figured in man hours per square yard, all labor employed on alley No. 1 equalled .498 man hours per square yard, while on alley No. 3 it equalled .865 man hours per square yard.

On alleys No. 3 and No. 4, two weeks were required on each to complete the work. Work was carried on with a half crew or a third of a crew of wheelers most of the time, owing to the contractors' unwillingness to pay full scale wages. The material was not well spaced, requiring long wheels, and the work was held up several times waiting for delivery of material. The labor cost on these two alleys was at least 25 per cent higher than it should have been.

We are indebted to Walter A. Heimbuecher, City Engineer, for the above information.

Widening Old Narrow Concrete Roads.—The County Road Commissioners of Wayne County, Michigan, are now experimenting with widening old 12 ft. wide concrete roads by digging out the loose stone shoulders and placing additional concrete pavement on either side. The old concrete is broken off so as to secure as strong a bond as possible.

Brick Street and Road Construction*

By WILL P. BLAIR.

Vice President National Paving Brick Manufacturers' Association.

In the construction of brick roads, we have not yet developed the use of tools and appliances to that extent which we should, which will lessen the actual labor necessary in brick street construction. However, this factor of construction economy is receiving attention and much progress has been made recently. The manufacturers of vitrified brick have had the courage to adopt a standard size paving brick, the dimensions of which are 3x4x8½ in. This is a distinctive step in economy, both in the matter of increased production and convenience in its use.

It is true that we have made progress out of the visualization which we are able to exercise through the long experience in the use of a great variety of types of brick pavement construction. We can almost unerringly draw out of this experience and observation many points of economy in the absence of knowledge of underneath soil conditions and the resulting behavior of the same, physical and climatic. Being obliged to accept these conditions, we can provide against some known behaviors. We do know that soils saturated with water under the influence of low temperature create an expansion almost irresistible in the force of its strength. This force irregularly exerted from underneath breaks and cracks the superstructure, if brittle in character, almost regardless of the strength of the superstructure.

We know that in the absence of such saturization pavements are not subject to such destructive force. Thus we see some brick pavements injured by this cracking process. We do not find the individual units of the brick pavement injured to any extent. On the other hand, there are hundreds of miles of brick pavements resting upon soils so thoroughly, naturally or artificially, drained that no apparent injury is exerted. The brick in such pavements held in aligument do not show any perceptible wear. The life, therefore, of such pavements is unknown.

Extremely moist conditions often, when not frozen, furnish such unstable support that shock-effect in the nature of crystallization finally exerts injury. Out of a study of these influences has grown a belief that a rolled broken stone base will so perform a drainage function as to stabilize soil support and at the same time afford sufficient voids that frozen moisture content will cause but little expansive force, so that a broken stone base is a great assurance against injury from frost action.

An added assurance against injury is the employment of an asphalt filler which possesses qualities of adhesion and cohesion sufficient to hold the brick in place and yet afford a yielding quality which results in an adjustment and readjustment following any expansive force.

Therefore, a combination of the two, a rolled broken stone base with a bituminous filler, unites against injurious effects in a most wonderful way. These qualities, thoroughly understood, combine an element of economy so great that it may be regarded as real progress in economy of brick road construction.

Curbs are required along the sides of the edges of city streets as a part of the gutter provision for the flow of water and as a wall to support the lawn or sidewalks at grade elevation. They form a part of the finish which contributes to the tasty appearance of the street. But how often do we come in contact with that influence which has grown out of conditions of years gone by, when great gutters were dug along the streets upon the theory that the surface of the street itself could be more readily drained thereby. Hence we have deep expensive curbing and unnecessary high crowns to streets for which there is no earthly reason. The crown of the street and the height of the curb should never be more than necessary for the proper surface drainage.

In highway improvement along routes not paralleled by sidewalks experience has shown that where monolithic or semi-monolithic construction is used by laying the brick in green mortar or mixture of sand and cement and filling the joints with a cement filler, curbs are not needed and are a useless expense.

Experience has also demonstrated that curbs are not needed where asphalt fillers are used. The practice of making the curb an integral part of the foundation is more harmful than beneficial. A trough is formed which holds the water, permitting it to subside into every chance crevice and opening in or underneath the pavement instead of the needful provision for an unimpeded flow from off and away from the pavement.

Experience has further shown that a curb independent of the base and set up against the pavement performs its supposed function with but little effect. The frost raises the curb out of place or, with a moistened condition outside the curb, it is easily pushed away, leaving the base without any embankment support whatever.

A gravel, broken stone or slag embankment or shoulder which would be subject to compaction by the occasional overlapping of vehicular wheels has proven a far better protection. A still better protection is a berm penetrated with a bituminous material which will allow readjustment of a possible displacement.

The curb for brick paved country roads is therefore largely a useless and costly appendage, incurring an expenditure of from $3,000 to $5,000 per mile that represents a waste pure and simple.

It has never been contended by any one that a curb built flush with the pavement was to bear any part of the traffic. In fact it never does. Then why not put the expense of the curb into additional width of wearing surface—to satisfy the growing demand for a wider roadway?

There are conditions upon hillsides and through heavy cuts where a curb becomes a necessity either for water disposal or for protection against water. But such are but mere exceptions to an almost universal possibility.

In the matter of specifications for road improvement our largest efforts have been in the direction of perfecting, by description and nomenclature, the materials out of which the artificial superstructure of pavements is to be made. We have diligently searched and provided for, as to what constitutes and how quality may be ascertained, both with reference to the units of material as well as by specific and understandable directions, as to how these materials may be brought together in placement to the best advantage.

The economic value of all of this, however, is dependent entirely on the agencies which injure and destroy this artificial superstructure and the units of composition. These agencies are recognized as arising from two sources. That of traffic on the one hand and on the other the behavior from natural causes of the underneath soil conditions. The destruction from traffic because of its visibility, has drawn from us our greater attention and study. But soil conditions, which exert a far greater influence on the durability of pavements than traffic itself, we do not understand. At the moment no engineer is able by any description, by any nomenclature, or by any classification of various characters of soils, to correlate them to such scientific treatment as will render injury on account of possible conditions, proof against injury to the pavement itself. We are so uncertain of our ability to characterize soil quality in relation to its ability to resist or influence moisture content by capillary attraction, that we merely visualize and we do sometimes say, drain here and drain there, as a kind of excuse or camouflage of our own ignorance, and in practice we install a pavement of exactly the same design, 5, 10, 15 or 20 miles in length, regardless of the condition upon which we place this track for traffic.

We are unable to direct how the sandy clay muck sections of our road or street sections shall be dealt with. Who knows in truth and in fact just what is meant by the unintelligible terms of clay plastic or muck soils. Why not be satisfied by saying stiff asphalt, shale brick or rock cement? If we do not say so in so many words we act as far as we do act, under the undefinable and uncertain term of "sufficient drainage." The absurd and unscientific way in which we have dealt with the underneath soil conditions in highway improvement, or our failure to deal at all with it, should bring us to realize that as highway engineers we have yet some work to do. To place reliance of sufficient support of traffic upon certain artificial slab strength of costly structure, without knowledge of what is already in existence, and regardless of its worth for that purpose or without knowing with what small relative expenditure certain treatment may render its condition inadequate, is but an acknowledgment of inability to economize and prevent great waste. Where, how and to what extent our drains shall be placed in each kind of soil to maintain in greatest stability we do not know, and, if we should know, we have no means of intelligent nomenclature to convey that to others to interpret our meaning.

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*From a paper presented at the 25th Convention American Society for Municipal Improvements, New Orleans, La., Nov. 11-14.

When we can classify or rate soils by some simple and inexpensive means of ascertaining its ability or limitation of capillary properties, and name the classification, and then correlate that soil to necessary treatment to maintain its stabilization and also to say what that treatment should be, we can then say whether our drains shall be 8 ft. apart or 20 ft. apart. Whether they shall be 3 ft. or 8 in. in diameter, whether they shall be 3 ft. or 4 ft. under the ground.

Uniform Highway Signs

The radius of travel on highways has increased in the past 10 years from 15 miles to 150 miles, hence the need for clear, distinct and uniform highway signs is 10 times greater today than it was 10 years ago. In view of this fact, the final report presented by the committee of the American Road Builders' Association at the annual meeting of the association Nov. 7, last, is of particular interest. According to this report the direction sign must be large enough to carry lettering that can be read at a distance of at least 200 ft. The letters must be plain, widely spaced and the contrast between the letters and the back-ground must be strong so that the name will stand out clearly. As the average rate of travel is 30 miles per hour in the open country, it is necessary that the lettering be large and clear enough to be easily read at that speed.

The precautionary sign should be of sufficient size to permit of wider spacing than that on the direction sign and symbols are found to be more quickly discernible than words. The word danger alone is not sufficient because the traveler wishes to know at a glance what the particular object to be on guard against is; to make this more clear the committee has adopted a bent spear with a red head pointing in the direction of the sharp curve.

The committee recommended that the sign of the state of Connecticut as further modified be adopted as a standard and that the arrow plan for direction markers be followed, with the name of the most important town on the route shown in a conspicuous place within the arrow and the two next intermediate towns placed in a less conspicuous place on the sign.

Other recommendations in the report follow:

The direction marker shall be 15 in. high by 36 in. wide; the sign to be constructed of either wood or metal; small arrows to be shown in front of the names of the two towns or cities shown above the main arrow; a system of coloring to be adopted showing the main and secondary routes, viz. black posts for north and south; white posts for east and west, these colors forming a ground for any symbol that a particular state may adopt for its main and secondary routes. Where these signs are located in a town, there shall be added on top the words: This is ———, giving the name of the town.

The precautionary sign shall bear the word danger in permanent red at the top and beneath the proper symbol for curves, railroad crossing and grades steeper than 7 per cent with the distance in feet to the impediment, which shall be, wherever possible, 500 ft.

All signs shall be supported on posts of either wood, iron or concrete and shall not exceed 7 ft. in total height above the ground.

The committee consists of R. A. Meeker, J. L. Bauer and T. J. Wasser.

Lighter Filler Used in Creosoted Wood Block Paving at Minneapolis.—During the past season changes were made in the character of the filler used by the city of Minneapolis in constructing creosoted wood block pavement. The new filler was used on about 50,000 sq. yd. of paving on the downtown streets with excellent results. During the hottest weather the streets were almost entirely free from bleeding, although the paving had only been laid a short time. The specifications for this filler are as follows:

Specific gravity at 38°-15.5°C	1.24
Specific viscosity at 82.3°C	35
Distillate up to 355°C	20 per cent
Specific gravity at 38°-15.5°C of distillate	1.015
Melting point of residue—cube method	95°C
Insoluble in chloroform	25 per cent

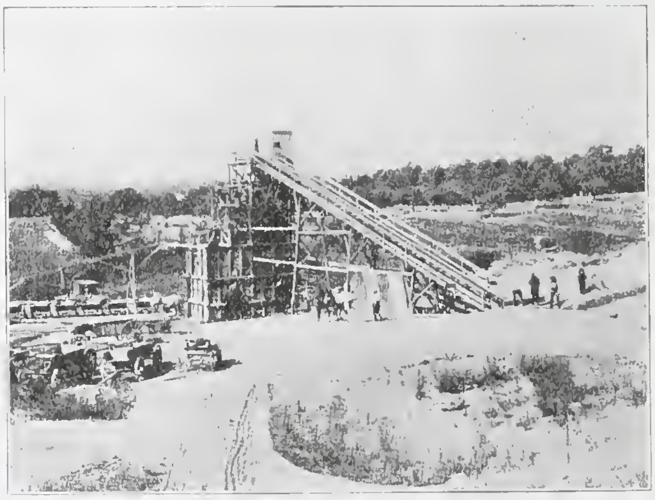
It will be seen by comparison with the usual specifications that the filler is much lighter and has more volatile material, and it is more like the fillers used some years ago when the ordinary filler was very much lighter than at present.

Cost of Operating Gravel Washing Plant at Wayne County, Michigan

Owing to the possibility of delays in shipment of sand and gravel through railroad congestion and on account of poor yard facilities near the work the County Road Commissioners of Wayne County, Michigan, leased a gravel pit and erected a washing plant to furnish material for two concrete road jobs carried out last year. The lease provided for a payment of 15 ct. per cubic yard in the bank, measurement to be governed by the number of cubic yards of concrete laid. A washing plant with a capacity of 200 cu. yds. per day was erected at the pit, the entrance graded and an industrial railway laid right up to the chutes from the washing plant bins.

The location of the pit was central to the road being built, thereby shortening the haul about ½ mile over the distance from the railroad siding if commercial material had been used. The lay-out of the gravel pit was such that it was much cheaper to arrange a yard at the pit than it would have been to unload from railroad cars.

A small stream fed by local springs furnished an abundant supply of water, which was pumped 1,000 ft. through two lines of 3-in. pipe to the washing plant by electric motor. A single line of 4-in. pipe would have been sufficient, but two 3-in. lines were used because this pipe was in stock. The plant was operated by a small electric motor, making it comparatively simple in operation.



Gravel Washing Plant of Wayne County Road Commission.

The cost of operation, exclusive of interest and depreciation, according to the last annual report of the Commissioners was approximately as follows:

	Total per day.
4 teams loading hopper at $8	$32.00
2 scraper holders at $5	10.00
1 foreman at $6.50	6.50
1 operator at $6	6.00
2 car loaders at $5	10.00
Motor rental at $1.50	1.50
Electric current, estimated	10.00
Total (200 cu. yd. at 38 ct.)	$76.00

On the basis of an average daily output of 200 cu. yd. the cost amounts to 38 ct. per cubic yard, plus 15 ct. for the cost of the material in the pit, making a total of 53 ct. per cubic yard for the material loaded in the industrial cars ready to haul. It will be noted in the above cost that the largest item is the teams loading the hopper which feeds the belt. This item could have been reduced by the installation of a drag line bucket and hoisting engine, but owing to the short run which this plant had it was not considered advisable to invest in so large an equipment.

The plant cost approximately $7,200 erected, and supplied about 10,000 cu. yd. of material, from the pit. It is expected to operate the plant next year for furnishing gravel and sand for maintenance work.

To Speed Up 1920 Road Building Program

In a letter sent out under date of Oct. 27 to the various State Highway Departments, Mr. Thos. H. MacDonald, Chief U. S. Bureau of Public Roads, points out that with $633,000,000 available in 1920 for the construction of surfaced highways it is vitally important to place under contract during December and January as great a mileage of roads as possible. The letter in full follows:

It is a matter in which the State Highway Departments may take a large measure of satisfaction that road building is the one big public activity which got under way early in 1919, which opened a large field for unemployed labor, which offered a market for construction materials, and which has continued to increase in volume as the months have passed. It is too early to have definite figures available for this year's production of roads and total expenditures, but it is estimated that the expenditures during 1919 for hard surfaced highways, exclusive of sand-clay and similar types, will total approximately $138,000,000. The largest previous year's total expenditures for like purposes, that of 1916, was $136,000,000.

But the test of the road building organizations is ahead. The estimated summary of the funds which will be available for highway work during 1920 for the construction of surfaced highways is as follows:

Brought forward from unfinished work, 1919 contracts	$165,000,000
Funds available from state and county taxes and federal aid	273,000,000
One-fifth state and county bond issues not before available	50,000,000
One-third of the unexpended balance of state and county bond issues previously available	45,000,000
Available from new bond issues to be voted on the fall of 1919 and spring of 1920	100,000,000
Total	$633,000,000

This large total is more than four times the amount of money that has been expended during any previous year for like purposes. To accomplish the physical undertaking of putting into actual road construction this sum or anywhere near this sum is tremendous. It is so much greater than any program that has heretofore been attempted that a great increase in the principal factors controlling the actual production of highways is absolutely essential. These principal factors are material supplies, shipping facilities, labor supply and contractors' organization. The acute deficiency of open top cars demands that our first attention be directed towards increasing shipping facilities for road materials. These facilities may be increased by two methods; first, by the more efficient use of open top car equipment, and second, by a large increase in the supply of new cars. During frequent conferences with the railroad administration it has become apparent that a more efficient use may be made of the present open top car equipment by starting the shipping season earlier than has been the general practice in the past. It has been customary to wait until contractors' organizations were ready to begin work before starting the shipment of materials. Under these conditions many thousands of open top cars lie idle during the latter part of February, all of March, and the earlier part of April. In the spring of 1919 the number of open top cars that were idle totaled more than 250,000. As the season advanced and road contracts were actually under way, the car shortage manifested itself here and there almost continously, but at three different times complaints received at this office were general.

We must recognize that if a strike threatens the railroads, road material will not be moved because it is not perishable. If the movement of coal demands the cars, there will be a shortage of cars for the movement of road materials. The importance of the movement of road materials must be impressed upon the public and the railroads, and for the present the road builders must correlate their calls for service so far as possible with the situation which exists—that at any critical moment when shipping facilities are involved, road materials will be the first to suffer.

Therefore, everything possible must be done to facilitate transportation of road materials under these handicaps. Railroad transportation has become too important a factor in the amount of work that can be accomplished to allow it longer to be regarded as incidental. It has become the biggest item in road production. Contracts should be awarded as early as possible that the contractors may know the amount of materials they will require at different points and they should be encouraged to place their orders for the materials requiring rail transportation as long in advance of the time they will be actually required as possible. The placing of materials in storage piles involves some expense, but this expense is small in comparison to the loss occasioned by lack of materials when the contractors' organization is waiting.

From the experience this year and in view of the greatly increased program for next year, it seems apparent that contracts which are not awarded during the winter months will have little opportunity of being supplied with materials which require rail hauling. Again contracts should be awarded early and contractors should be encouraged to place their orders so that the material producers will operate their plants during all seasonable weather. In the past, too many contracts have been held until later in the year and material supplies have not been started moving during the period when the car supply is at its maximum. Also, contract prices have usually been lower for work awarded early in the season, and the state departments and the Federal bureau must recognize and respond to the public confidence which has been shown by the appropriations of large sums for highway improvement, by adopting every method that will help to secure the lowest prices and the most efficient expenditure of these funds.

In view of the greatly enlarged program of road construction and the large amount of unfinished contracts which will have to go over because of lack of road materials, it would seem unnecessary to further accent the need for taking advantage of the supply of open top car equipment in February, March and April.

It is apparent that many contractors who have not before been so engaged are looking to the highway field, and that the contractors' organizations will be expanded. The labor shortage may in part be met by improved machinery and equipment, but the transportation and the supply of materials cannot be so readily or quickly expanded to take care of the greatly increased needs. Unless a forward looking policy recognizing these conditions is adopted at once, it is not apparent that a greatly increased production of roads will be possible next year over the miles constructed this year, yet the public is demanding of road building organizations a greatly increased production.

Every official in an administrative capacity in the road building organizations knows that it is common for the public to demand great activity and immediate production of roads as soon as bonds have been voted. The fact that more than four times as much money is available for roads next year than has been true heretofore means that these demands will become intensified and it will be a difficult task to impress upon the public the fact that the production of roads is controlled by factors largely outside of the control of the highway officials.

The only possible relief is to use the present transportation and materials production agencies in the most efficient manner possible and at the same time bend our efforts to obtain an increased car supply and an increased production of road materials. But these policies, to be effective, must be adopted by the state departments and the Federal bureau individually and collectively, at once, and the first step is to place under contract during December and January as great a mileage of roads as possible. In doing this the Bureau wishes to cooperate with and aid the states in every way possible.

Road Grading Outfit Moves 1,000 Cu. Yd. Per Day.—In constructing the Federal aid road project from Kearney, Neb., to Pleasanton, the contractor, A. L. Cook, of Ottawa, Kan., has been excavating approximately 1,000 cu. yd. per day. His outfit consists 15 mule teams, one elevating grader, one 8 ft. grader, four 1 yd. dump wagons, four 4 ft. fresnoes and one road plow. Wages average $4 to $5 per 10 hours. Camp board is $1 per day. The grading calls for the moving of 170,000 cu. yd. of earth. The road is 20.4 miles long, of the earth type, and is 24 ft. wide.

Wayne County Concrete Resurfacing Job Successful.—In June, 1916, the County Road Commissioners of Wayne County, Michigan, widened out a section of a concrete road from 16 to 20 ft. and resurfaced with 3 in. of reinforced concrete. In their annual report for the year ending Sept. 30, 1919, they have the following to say regarding this work: "Its condition for all practical purposes is as good as the day it was opened to traffic, and we consider it beyond the realm of an experiment, and an unqualified success in every particular."

Solving Snow Problem on Highways

The snow problem is becoming one of considerable importance to road officials. This is due to the increased use of the roads, and more especially to the increased amount of motor truck traffic which is very seriously handicapped by the snow. There will be a greater demand each winter to keep open many of the main roads for automobile and motor truck traffic. Useful suggestions for keeping the roads open for motor traffic during the winter months are given in a bulletin prepared by Mr. A. H. Hinkle, Deputy Highway Commissioner of Ohio. The following is taken from the bulletin:

Causes of Drifts.—To solve this problem by preventive methods, it is necessary to begin the study of it during the preceding winter. For instance, snow drifts do not come by chance. The snow drifts much deeper in some places that other places for a reason. There is always a cause for the drifts and if the cause is removed, the drift will not form. Hence there arises the necessity of observing one winter the location of the bad drifts and their cause, and then attempting to eliminate that cause before the approach of another winter.

The drifting of the snow will take place where the velocity of the wind is checked by some obstruction. The snow is deposited in drifts for the same reason that a sand bar is deposited in a stream where the velocity of the water is reduced, thus allowing the sand or silt which was carried by the swifter moving water to settle to the bottom. It will be observed in the climate of Ohio that the north and south roads are usually drifted much worse than the east and west roads. This is due to the prevailing direction of the winds which is generally from the west, together with the fact that the obstructions causing the drifts are usually found paralleling the road. Owing to the prevailing westerly winds an obstruction on the westerly side of a road is many times more objectionable than on the east side.

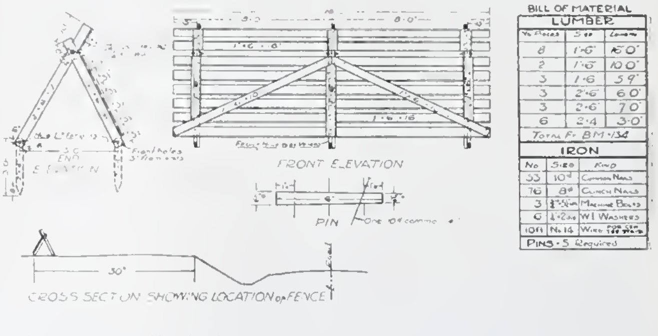
Upon investigation it will frequently be found that snow drifts in the road have been caused by a fence along the road. Rail, board, picket, and especially hedge fences, are very common causes of snow drifts in the road. They check the current of air enough to cause a drift to form. Hills or high banks, where there are cuts in the road, will frequently be sources of drifting snow. Bush rows along the road will invariably cause drifts to form. Even a few weeds, although innocent looking, may check the current of air sufficiently to cause it to deposit its load of snow.

A row of weeds along the road shoulder may be the source of considerable annoyance by causing snow to drift on a road which is well above the surrounding country.

Removing Obstructions Which Cause Drifts.—It is readily seen from what is given above, that a method of preventing the snow from drifting would be to remove the obstructions which check the current of wind. This can frequently be done. Low bushy trees can be trimmed. A tree trimmed some distance from the ground will ordinarily not be a serious source of drifting snow on the highway. Fences of the type mentioned above should not be constructed along the highway. We cannot always in justice to the farmer tear down a good fence; but we can discourage the use of such fences along a highway as will be a source of future trouble in causing snow to drift. However, the seriousness of the case will frequently justify the removal of certain fences. A wire fence will not cause the snow to drift because it offers little or no obstruction to the wind. A hedge, board or picket fence on the west side of a north and south road should not be closer to the center of the highway that 50 or 60 ft. Weeds and brush on the road shoulder and outer edge of the right-of-way should be kept cut. This can not be emphasized too much because solving the snow problem is only one among many other reasons for cutting them. The higher the roadbed, the less will be the trouble from drifting snow. Hence, we should, when designing our road, give this matter consideration. The roadbed may some times be elevated in those places where due to the topography and the surrounding conditions there will be a tendency for drifts to form. It must be remembered that we are justified in going to greater expense in eliminating this trouble on the more important thoroughfares and especially the north and south roads, because of the greater tendency of drifts to form thereon.

Use of Snow Fence.—Of course we will not be able to remove a hill where it is the cause of drifting snow; but there is another means of prevention which may be used in this case. Since it is an obstruction that causes drifts to form, it is readily seen that, if the obstruction were back some distance from the highway, it would be a relief by causing the snow to be deposited before it reaches the highway. Hence, by the construction of some obstruction, let us call it a snow fence, some distance away from the highway we may largely prevent the drift from forming on the road.

In Fig. 1 is given a design of a portable snow fence. Instead of using stakes to anchor the fence to the ground as shown in the illustration, a board may be nailed to the bottom of the two legs to holi the fence erect. When this is done, it is necessary to increase the angle of inclination of the fence to the ground in order to make it sufficiently stable to prevent it from blowing over. A picket fence with pickets placed closely together may be temporarily erected for this purpose. It is readily removed, as it can be detached from its supports and rolled up in sections in the spring and laid away until the next winter. The picket fence may be fastened to posts driven into the ground. One and one-half inch hollow iron posts or 1¾ in. x 1¾ in. x 3/16 in. angle iron or 3 in. to 4 in. locust posts may be used for this purpose. The posts can be easily pulled in the spring of the year when the ground is soft.



Note Slats shall be spiked to posts with 10d common nails; battens to slats with 8d clinch nails. Stakes and pins shall consist of good white or burr oak. All other timber shall be of good quality pine or cypress. The lower 18" of posts shall be given two (2) coats of liquid creosote oil. Pins shall be dipped in creosote oil.

Fig. 1—Portable Snow Fence Designed by Bureau of Maintenance and Repair, Ohio State Highway Department.

A portable fence would be used where it is necessary to remove the fence during the summer so the fields could be cultivated, or for other causes.

A stationary snow fence might be made by spacing 6 in. boards 2 to 3 in. apart on posts set vertically in the ground to a height of about 6 ft. above the surface. However, where the land is under cultivation, it would not be practical to use a stationary fence. In such places, if a snow fence is used at all, one of the portable designs would have to be adopted.

It should be observed that the proper location for a snow fence is some distance back from the edge of the highway. The distance will vary according to the height of the fence. The distance from the edge of the road would be 8 to 10 ft. per foot of height of the fence.

Owing to tne expense of constructing a snow fence and the erecting and removing of it every year, the preventive methods previously described should be resorted to wherever possible, before resorting to the use of snow fences. It may not be practical to use a snow fence except in extreme cases where the snow drifts badly every year onto very important roads.

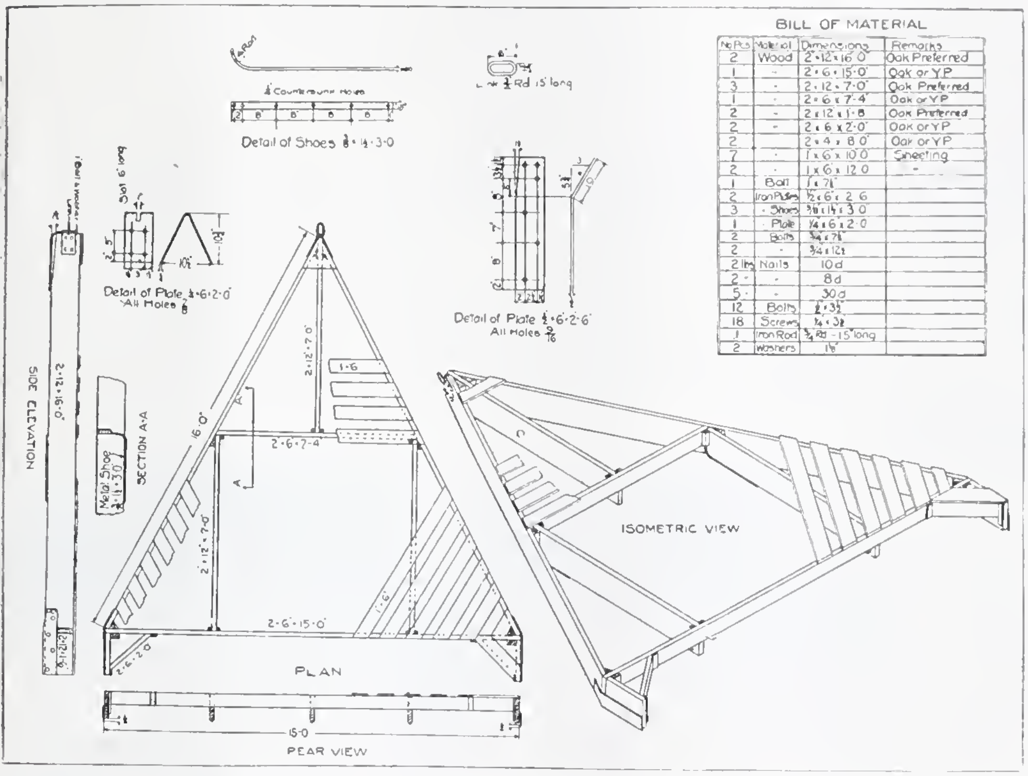
A careful study of the causes of drifting snow at any particular place will be of great value in solving the problem. It must be kept in mind that the direction from which the wind comes is a determining factor in the location of the drifts. However, inasmuch as the majority of our winds are from a westerly direction, the location of drifts will frequently be in the same place.

Snow drifts cannot always be eliminated. Neither can a heavy fall of snow be prevented. This will compel us to deal with this subject from the second point of view.

Handling Snow Drifts and Heavy Snow Falls.—Three methods of dealing with the snow problem, when the snow cannot be prevented from drifting onto the road, present themselves: (a) Driving in Fields; (b) Compacting Method; (c) Removal Method.

On secondary roads that drift badly, it is customery in places to drive across the fields in order to avoid the drifts in the road. However, because of fences and objections to trespassing on private property, this practice can be followed only in certain places even on secondary roads, and the custom would never be practical on heavily traveled roads. Hence, the present road must be made passable for traffic.

How the Snow is Compacted.—One way of solving the problem of a heavy fall of snow on a country road is to uniformly compact it by the use of a roller. A roller 5 to 6 ft. in diameter and 10 to 12 ft. long is perhaps best suited for this purpose. The roller should have closed ends in order that it can be pulled most easily over the snow. The rolling should be done when the first fall of snow comes and when the layer of loose snow is not more than 8 in. to 10 in. deep. As more snow falls, or "blows" come, causing the snow to drift, the rolling can be repeated as many times as is necessary. The object sought is to compact the snow sufficiently hard to carry the traffic thereon. With continued snows and rolling, this process will build up the surface to such a height that the snow will drift less thereafter on the traveled roadway. It is important that the rolling be done over a sufficient width that vehicles can readily pass without getting off into the loose snow.



No Pcs	Material	Dimensions	Remarks
2	Wood	2"×12×16'0"	Oak Preferred
1	"	2×6×15'-0"	Oak or Y.P.
3	"	2×12×7'-0"	Oak Preferred
1	"	2×6×7'-4"	Oak or Y.P.
2	"	2×12×1'-8	Oak Preferred
2	"	2×6×2'-0"	Oak or Y.P.
2		2×4×8'0"	Oak or Y.P.
7	"	1×6×10'0"	Sheeting
2	"	1×6×12'0	"
1	Bolt	1×7½"	
2	Iron Plates	½×6×2'6	
3	" Shoes	⅜×1½×3'0"	
1	" Plate	¼×6×2'-0	
2	Bolts	¾×7½"	
2	"	¾×12½	
2 lbs	Nails	10d	
2 "	"	8d	
5 "	"	30d	
12	Bolts	½×3½	
18	Screws	¼×3½	
1	Iron Rod	¾ Rd - 15" long	
2	Washers	1½"	

Fig. 2—A-Shaped Snow Plow, Designed by Ohio State Highway Department, Bureau of Maintenance and Repair.

For ordinary horse-drawn traffic, and perhaps a very light auto traffic only, the compacting method described above is very satisfactory and very economical. However, for heavy auto and motor truck traffic which goes over many of our main thoroughfares, this method is not at all satisfactory. The snow can not ordinarily be sufficiently compacted to form a suitable surface for such traffic. As a result bad ruts will be formed in the compacted snow which will make it almost impossible for vehicles to pass. Also, the snow not forming sufficient tractive resistance for the wheels, they will "dig in" and bury themselves in the snow and the truck or heavy machine will be stuck. This method is especially troublesome during thaws.

While the method of removing the snow from the road surface will be more expensive than the compacting method, it is a method which must be used on such roads as are expected to satisfactorily accommodate motor truck and heavy auto traffic during the winter season.

Methods of Removing Snow From Road.—Various machines and methods of removing snow from the highways have been used. For ordinary depths of snow there may be used a road grader pulled by horses or a caterpillar tractor, a snow plow pulled by horses or tractor, or a plow attached to the front of a motor truck. For opening up a passage through heavy drifts hand methods or power sweepers will have to be used.

An ordinary road grader is an excellent machine for scraping the snow from the road surface. Iron shoes placed under the grader blade to prevent it from gouging into the pavement or catching on some slight projection are sometimes used. A heavy road grader is desirable in order that it will not be shifted sidewise by the snow. Three, four or six horses may be used to pull the grader as the depth of snow and weight of grader will demand.

An A-shaped snow plow is sometimes used for opening a track in the road. This can sometimes be used where the depth of snow is too great to use a road grader. It will of course be necessary to use enough horse power to readily pull the plow through the deep snow. In order that the plow will travel in a straight line down the road, the length of hitch should be as short as can be conveniently made. The plow can be made to vary in weight as the conditions of the snow will warrant.

A snow plow attached to the front of a motor truck has been used to a considerable extent in removing snow from the road. It cannot be made to operate in deep snow as in the case with the road grader; however, it has a big advantage in being speedy and can be used to keep the road clear while the snow is falling. These snow plows are attached in front of an ordinary motor truck and have been used with most excellent results.

The use of a power driven rotary sweeper similar to that used by electric railways to clean their tracks, or the use of a side elevator machine for opening up large drifts would seem to be a possibility. Owing to the fact that there is a greater demand each year for cleaning the road of snow it is possible that some such machinery will be developed for this purpose in the future.

Where heavy drifts have formed, it may be necessary to clear the road by "Hand Methods." Large shovels should be used for this purpose. Inasmuch as the hand method of clearing the road is very expensive, machines described above should be used wherever and whenever possible. By continually operating the machines mentioned above during the storm, hand methods can be largely avoided. Where this can not be done, or where it is not done in time to prevent drifts, openings through the snow drifts will have to be shoveled out by hand.

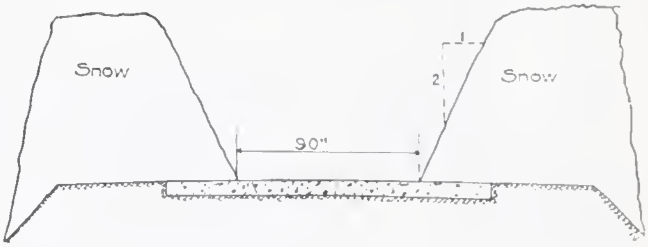


Fig. 3—Minimum Clearance Through Snow Drifts Required for Heavy Truck Traffic.

Width of Road to be Cleared.—The width of road to be cleared of snow will depend upon the kind and amount of traffic to be accommodated. Ordinary farm traffic consisting of horse-drawn vehicles and light pleasure motor cars will be accommodated by a minimum clearance of 6 ft., while the heavy motor trucks will require a width of not less than 8 ft. For this latter kind of traffic, even through high snow banks, it is desirable to make a clearance of not less than 9 ft. A double track width, even in high drifts where the drift is continuous, should be cleared at intervals to permit vehicles to pass. The amount of traffic on main thoroughfares will usually warrant the clearing of the pavement to its full width. Clearing the surface of snow for its full width will also frequently be a saving in the maintenance of the highway by reducing the tracking of vehicles which is very destructive to certain types of pavement.

When starting first to clear the road of snow by the use of machines, it is very necessary to scrape the snow farther back than is really necessary for the time being in order to have room for the snow to be removed on successive cleanings. This, of course, would apply more especially where the snow is removed with a snow plow or road grader rather than where it is shoveled out through large drifts.

In scraping and shoveling snow from the road it is very desirable that the removed snow, so far as possible, be piled on the opposite side of the road from the prevailing direction of the wind, in order to reduce future drifting on the highway.

In the first operations of scraping the snow from the highway by the use of a road grader, or a snow plow attached to the front of a truck it may be most economical when later work is considered, to scrape the snow in but one direction in order to reduce future drifting on the highway. It must be remembered that a pile of snow will cause a drift to form on its lee side just as much as will other obstructions.

Maintenance Cost of Bituminous Pavement at Portland, Me.

Maintenance costs for three sections of state highway constructed in 1908, 1909 and 1910, in the city of Portland, Me., are given in the annual report for 1918 of Edward M. Hunt, Commissioner of Public Works of Portland. The first section (completed in 1908) consists of bituminous macadam (penetration method) laid in Danforth and Vaughn Sts., for a total length of 2,879 lin. ft. and a yardage of 8,657 sq. yd. The cost was $1.13 per square yard. Section 2 covers 2,683 lin. ft. of bituminous concrete (mixing method) laid on Vaughn St. in 1909 at a cost of $1.03 per square yard. The total yardage is 8,807. Section 3 is also bituminous concrete. This was laid in 1910 on Cumberland Ave. at a cost of $1.31 per square yard. The total length of this section is 1,702 lin. ft. and the total yardage is 6,398. These pavements are maintained by the city. The unit cost of this for the past 10 years has been as follows:

SECTION 1—BITUMINOUS MACADAM; LAID IN 1908; ORIGINAL COST, $1.13 PER SQ. YD.

	Repairs.	Surface treatment.	Total maintenance	Total. Repairs and maintenance per sq. yd.
1909.........	$ 90	......	$ 90	$0.0104
1910.........	293	$ 307	600	0.0691
1911.........	69	246	315	0.0363
1912.........	72	158	230	0.0266
1913.........	96	97	193	0.0223
1914.........	98	100	199	0.0229
1915.........	61	127	188	0 0217
1916.........	106	......	106	0.0122
1917.........	180	233	413	0.0476
SECTION 2—BITUMINOUS CONCRETE; LAID IN 1909; ORIGINAL COST, $1.03 PER SQ. YD.				
1910.........	$ 332	$.....	$ 332	$0.0378
1911.........	100	406	506	0.0575
1912.........	1,340	66	1,407	0.1597
1913.........	1,055	37	1,092	0.1240
1914.........	98	152	250	0.0284
1915.........	50	208	259	0.0294
1916.........	......	......	......	......
1917.........	24	89	113	0.0128
SECTION 3—BITUMINOUS CONCRETE; LAID IN 1910; ORIGINAL COST, $1.31 PER SQ. YD.				
1911.........	$ 105	$ 447	$ 552	$0.0863
1912.........	449	......	449	0.0702
1913.........	761	......	761	0.1190
1914.........	312	165	478	0.0747
1915.........	293	113	406	0.0635
1916.........	257	110	367	0.0573
1917.........	102	357	459	0.0718

Prize Contest for Articles on Street Cleaning.—The Elgin Sales Corporation of New York and Chicago has offered a first prize of $100 and a second prize of $50 for the two most interesting articles or stories on the subject of street cleaning. Contributions of not over 800 words are preferred. Unless a contribution of more than 1,000 words has distinct merit, it will not be considered. All manuscripts must be mailed to Geo. C. Dodge, care Elgin Sales Corporation, 501 Fifth avenue, New York City, and only those received on or before Feb. 15, 1920, will be considered in making the awards.

Recent Developments in Concrete Highway Construction*

By A. N. JOHNSON,
Consulting Highway Engineer, Portland Cement Association.

The subgrades should receive more attention. It is desirable to have the bottom of the concrete slab as nearly a true surface as the top. Where heavy clay soils are encountered it is better not to roll the subgrade to any extent but shave down the final inch or two by hand or with a subgrading machine. Evidence exists to prove that heavy rolling of many soils results in subsequent disturbance of the pavement; for these soils, as soon as any moisture reaches them, swell and actually heave the pavement.

Street corners should be rounded to a radius of not less than 20 ft.

The construction of concrete streets makes possible the use of integral curbs, which are not only more economical, but are readily constructed, present an excellent appearance and avoid any chance of displacement which so often occurs with separate curbs. The face of the curbs should not be perpendicular but should have a slight batter so that the upper corner will not come in contact with the rims of motor vehicles.

Grading of Aggregate.—Much progress has been made in our knowledge of the use of variously sized aggregates and their proportioning for concrete mixtures. This has been made the subject of most exhaustive study and investigation by Professor D. A. Abrams of the Lewis Institute, Chicago. The results that he has obtained have shown that the arbitrary divisions of fine and coarse aggregate by sizes to be found in many specifications do not necessarily give a grading that will produce the best concrete or, in fact, be even a measure to indicate the relative value of various aggregates. If many of the gradings specified for fine aggregates were strictly enforced it would result in the rejection of much material from which as good concrete could be made as with material that would be accepted under a particular specification. Those who may be interested to refer to Professor Abrams' work may consult either the Engineering News-Record, April 17, 1919, or the Engineering and Contracting, April 23, 1919.

Consistency.—One point on the subject of mixing concrete should be mentioned, which is, the great importance that the amount of water exercises on the strength of the resulting concrete. The less water that is used, compatible with securing a mixture that is workable, the stronger the concrete will be. This fact, but recently understood, is a further result of the investigation of Professor Abrams.

In order to measure the consistency and make a definite specification therefor, there has been developed what is known as the slump test. This is most satisfactorily performed by the method devised by Mr. F. L. Roman, testing engineer of the Illinois State Highway Department. He uses for the purpose a light metal mold in the form of a truncated cone 12 in. high, having an 8-in. base and a 4-in. top, into which the concrete is placed. The conical shell is removed by means of handles attached to the mold and the resulting slump in the concrete is noted. This method, Mr. Roman has demonstrated, gives very consistent results and is a better measure of the consistency than if a cylinder is used to make the slump test. The amount of slump for concrete to be placed with a finishing machine should be about ½ in. to 1 in., a trifle greater allowance being made for concrete with rounded pebble aggregate than with crushed stone aggregate.

Improved Methods of Finishing.—Aside from improved methods of handling materials the developments in concrete road construction have been chiefly improvements in methods of finishing. Of these, the first place must be assigned to the roller. The roller that is used in finishing a concrete pavement consists of a light metal cylinder 10 or 12 in. in diameter, about 6 ft. long, weighing not to exceed 100 lbs. On roadways 18 ft. or over in width the roller is most conveniently and effectively operated by means of ropes attached to a double bail. Two men, one on either side of the pavement, pull the roller back and forth over the freshly laid concrete. This operation is repeated at intervals of 10 to 20 minutes, as often as there rises to the surface a film of water which the roller squeezes off to the edges. This water, if it remained in the concrete, would greatly lessen its strength and if not removed from the surface there would form a thin layer of laitance, which is very apt to scale and present an undesirable appearance.

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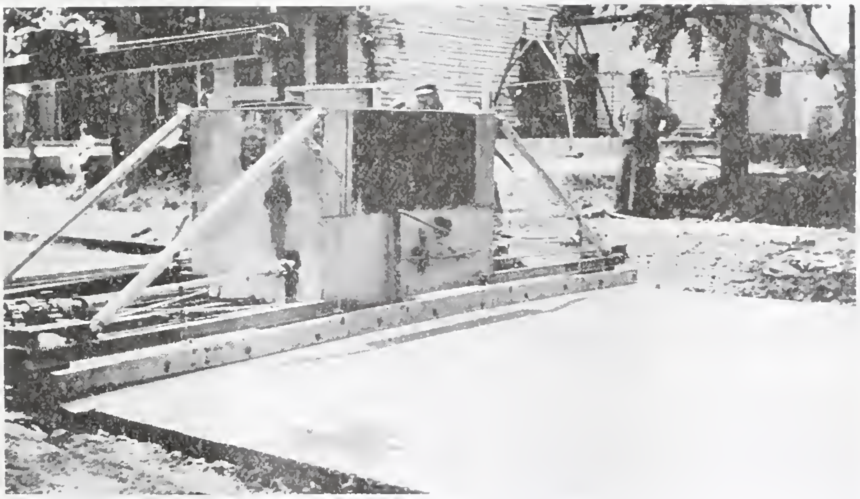
*From a paper presented at the 25th Convention of the American Society of Municipal Improvements, held Nov. 11-14, at New Orleans.

After the pavement has been rolled not less than four and possibly five times it is finished with a broad canvas belt or thin board. The belt or board is drawn over the surface with a seesaw motion and leaves a uniform even finish to the concrete. Excellent results have been obtained by attaching a belt to a thin board which serves as a bow by which the belt is stretched.

Previous to using the roller a heavy tamping template should be employed or, in the case of street work which may be too wide to use such a template, the surface should be hand-tamped.

An interesting point in connection with the development of the use of the roller is the fact that while the roller and its effect upon newly laid concrete are described by Mr. E. L. Ransome in the 1910 edition of Gillette's Hand-Book of Cost Data, its general adoption as an adjunct to concrete road construction was not until 1917.

Mechanical finishers have now been developed that are used very successfully upon roadways up to 20 and 24 ft. in width; and are being constructed to operate upon even wider roadways. These machines shape the concrete, at the same time tamping it, and are also provided with automatic belting arrangement. Concrete of a comparatively dry consistency is required if the best results are to be obtained. In the event somewhat too large a quantity of water is used the effect of the tamping is to bring considerable water to the surface. These machines should then be followed with a roller to be sure that the excess water on the surface is removed and not allowed to stand upon the fresh concrete. Such a machine to be successful must be easily reversible so as to be operated a number of times over the same area.


Finishing Machine for Concrete Roads.

An important object to be gained by using the roller or finishing machine over a given portion of the concrete surface for a number of times extending over a period of 30 or 40 minutes is to keep the concrete plastic during a long enough period to overcome the formation of minute shrinkage cracks that may occur with the initial set and which may develop where the concrete is given but one application, either of the roller or the finishing machine. If it is noticed that shrinkage cracks still occur, then the operation of the machine or roller should be continued for a longer period.

Belt Finishing Concrete Road.

Use of Machinery in Concrete Road and Street Construction.—The time is approaching in fact has approached, when to employ unnecessarily a number of men upon a given job is little short of an economic crime. More than ever attention must be given to the application of machinery and labor-saving devices in all forms of construction; and this applies with special force to paving work, where there is opportunity for much improvement.

The construction of concrete pavements lends itself very readily to labor-saving devices, many of which have now been perfected so that today it is practicable to lay concrete pavements with a minimum of hand work; that is, nearly every man upon the job will be operating machinery. On the average for concrete highway work there need be required but four or five men doing only hand work.

A central material plant where materials are unloaded by power, transported thence to the work on a narrow-gage industrial track, thence to be lifted by derrick to the mixer, constitutes an economical set up. This method of hauling the materials enables the work to proceed through bad weather when team hauling would be impracticable; the number of men necessary is greatly reduced from the old method of placing materials upon the subgrade and shoveling thence into the mixer; the materials themselves are kept cleaner, are not wasted to the same extent, and the subgrade remains in better shape. In general, to place materials directly on the subgrade is a clumsy, costly and defective way of doing the work.

A recent development is to handle the concrete from a central mixing plant, and under many conditions this promises

Central Proportioning Plant for Branch County, Michigan, Roads.

to be one of the most economical and expeditious methods of laying concrete pavements. It should have particular application to the laying of concrete streets when the concrete may be mixed at the railroad yards or nearby where materials are received, and hauled to the work in trucks. In this way the particular street to be paved need not be encumbered by any materials, may remain open to traffic up to the last minute, and kept closed for a minimum period.

To insure rapid prosecution of work the contractor should be required to assemble a sufficient amount of materials to insure that no delays arise on this account.

Recent experience in handling concrete in bulk demonstrates that this is not only thoroughly practical but is economical. A good method is to deliver the cement in open-top cars protected by tarpaulins. To use cement delivered in this manner economically it is necessary that the job be of such size as to warrant building cement-storage bins capable of holding from 25 to 50 cars of cement. The cement is readily unloaded by means of a clam-shell bucket.

Central Loading Plant for Street Paving at Spencer, Ia.

The storage bins required for the sand and gravel need be no larger than is necessary to hold a sufficient amount to fill one or two trains of the small cars. The principal storage should be in storage piles. An excellent arrangement for these is to depress the track so that there will be a tunnel made beneath the storage pile and no storage bins are then necessary.

Alley Construction.—An economical method for handling alley work is to have the materials delivered at the head of the alley on an adjoining street, where this is practicable. The mixer is stationed nearby and the mixed concrete delivered by small gasoline-driven buggies.

It is a good practice in laying an alley that abuts upon buildings or high fences first to lay a form about 18 in. from either edge of the alley and fill the concrete behind this form adjacent to the buildings or fences. This strip on either side finished, the forms are removed, and the center of the alley is placed, the side strips offering a place for the workmen to finish with facility the center portion of the alley.

Where it may be necessary occasionally to gain access to pipes or conduits the procedure would then be to lay a narrow strip of concrete directly over the line of the conduit separate from the remainder of the pavement. It is assumed that this strip will be at the center of the alley. First one side will be laid, then the other and last the 18-in. or 2-ft. space at the center. There should be no joint material put in but the edge of the concrete before placing the center portion may be painted or oiled, in this way assuring ready removal of the center section whenever it may be necessary. When finished the joints should be practically unnoticeable.

Use of Reinforcement.—The function of reinforcement in concrete roads seems to be a matter of some confusion. The amount of reinforcement which is generally used and beyond which amount it is not practicable to go, does not to any great extent reinforce the concrete slab in the sense that a concrete beam or girder is reinforced by steel rods. That is, no great increase of structural strength is produced. The chief effect secured is not so much the prevention of cracks as to prevent cracks that do form from opening and becoming of any appreciable width; so that the chief function of reinforcement in concrete roads is to hold the concrete slab together after it may have cracked.

Some have contended that if reinforcement were used a thinner slab might be employed than if no reinforcement were put in the pavement. If the amount of reinforcement were 10 to 20 times as much as is used there would be some ground for such contention, but where the amount of steel does not exceed 40 to 50 lbs. per 100 sq. ft., and usually it is considerably less, the increased strength given the slab is so slight that it is practically negligible in so far as being able to reduce by any appreciable amount the thickness of the slab. The best reinforcement to increase the strength of the slab is added thickness. This not only gives a much stronger slab but also one of greater weight and therefore of greater inertia, which is of importance when the nature of the loads and shocks produced thereby are considered.

General practice today regarding reinforcement is to use it on those portions of the road where the greatest disturbance is expected in the subgrade as, for example, on clay hills. It is also the general practice to reinforce streets where it is desirable to hold to a minimum in size such cracks as may form. There is also an increasing tendency to use larger metal units of reinforcement, that is, larger bars spaced further apart, rather than smaller ones spaced closer.

Reducing Prices for Pavements.—Whenever a contractor is in doubt, when he is confronted with uncertainties, when he must assume certain hazards, he endeavors to secure himself against possible loss and make his bid price accordingly. At the present in most paving contracts the contractor must assume all the hazards and in proportion to the degree of risk to be incurred does the bid price increase.

The hazards to be encountered may roughly be divided into two classifications. First, those which, although perhaps inevitable, it is nearly impossible, even after the work is completed, to assign just to what extent the cost to the contractor has been affected. Under this heading would fall the hazards due to weather conditions.

Loading Plant, Near Laurel, Del.

Of the second class are those hazards which, when they occur, their financial effect upon the contractor can be definitely calculated. In this class would come a change in freight rates during the term of the contract. Under such conditions the contractor can readily show definitely how much more or less the work cost, due to the difference in freight rates on the materials involved. These two examples are perhaps sufficient to indicate the difference in the nature of the hazards which every contractor making a bid must consider.

The added price he must charge is in the nature of insurance. If the risk were removed then there would be no need for an insurance charge and the bid price should be that much less. It is submitted that, certainly as to those risks which come under the second classification, the public can insure itself to much better advantage and assume itself some of the risks for which contractors now make a very considerable charge.

Contracts should be so drawn as to relieve the contractor of every uncertainty and hazard that it is possible to foresee. Surely every contract should provide for an adjustment to be made in case freight rates are changed subsequent to the execution of a contract: if increased then additional compensation for the contractor, if reduced like advantage to the public. If, in order to hasten completion of the work and avoid delays costly to both contractor and the public, it is desirable to store quantities of materials ahead, allow the contractor a fair advance upon such materials. If a contractor is required to store materials but paid only for completed work he must charge for this service and the risk incurred. And this charge will be more than the cost to the public to advance to the contractor the money necessary to pay for the materials stored.

But it is not so important here to give specific examples as to call attention to the general principle that lower bid prices will be secured upon street and highway work to the extent that the contractor is relieved of risks. The engineers in the public employ could well consider carefully every chance and hazard that may arise during the prosecution of a given paving project and so draw the specifications and contract as to relieve the contractor of every uncertainty possible. The method that imposes upon the contractors all the risks and requires him to do all the guessing is both costly and unbusinesslike.

Recommendation for Reconstruction of Narrow Highways for Motor Truck Traffic

Realizing that it would be unwise to draw definite conclusions from factors which are still indefinite in the building of roads and pavements, the committee on "Reconstruction of Narrow Roadways of Trunk Highways with Adequate Foundations and Widths for Motor Truck Traffic" submitted only a report of progress at the annual meeting Nov. 7 of the American Road Builders' Association. In the report the committee reaffirmed its recommendation on width; that is, that the paved surface of the roadway on truck highways should be at least 20 ft. in width. For each additional line of traffic 9 ft. more should be added.

The committee recommended that the minimum width of the shoulder be 5 ft., except in cases where new right of way is to be acquired; then the additional width shoulder should be at least 9 ft., in order that, should additional traffic require it, four lines of traffic may be accommodated without requiring additional right of way.

The recommendation that the present drainage systems be examined and placed in such condition that they will function properly was reaffirmed, and it was suggested that where under drains are necessary they be placed alongside of the pavement, and not directly under it. The advantage of this method is that they can be cleaned without disturbing the pavement surface, and to a large extent safeguarded from vibration which has a tendency to fill them up. It has been found in many cases that a line each side of the pavement requires less linear feet of drain than a single line with spurs running under the pavement.

For new pavement construction the committee reaffirmed its recommendation that all foundations be of concrete or other suitable material. Where the present pavement can be utilized the committee recommended that the widening be of the same kind of construction as the portion to be utilized. Where, however, it appears feasible to anticipate future needs, it was recommended that the widening be of a type appropriate to them. It was suggested that when widening a pavement, edging be used to prevent lateral movement.

No definite conclusions have been formed as yet with regard to bituminous macadam foundation. The cases that have been brought to the attention of the committee are so limited in extent that the committee was not prepared to make a definite recommendation at this time.

For pavement surfaces the committee recommended that pavements on trunk line highways be of concrete, brick, wood block, stone block, asphalt block, bituminous concrete (of the mixed type) or street asphalt.

The committee suggested that all detours be made adequate for the traffic that they must carry; that they be maintained during the time of detour and that they be put in passable shape at the completion of the work. The expense of the detours is to be assumed by the governing body doing the main construction work.

Where there are two main lines in the same direction between two centers of population only one should be improved at the same time, in order that traffic may have one through route at its disposal.

The committee recommended a thorough study of line and grade in order that sharp turns and steep grades may be eliminated at the time of reconstruction. It was suggested that greater safety may be had by cutting back existing banks on the inside of curves, thereby giving greater sight distance. In all reconstruction work curves should be eased to give a greater sight distance.

The committee consists of H. Eltinge Breed, chairman; Professor T. R. Agg, Major Fred. A. Reimer, W. G. Thompson, Lt. Col. W. D. Uhler, Chas. M. Upham.

Comparative Durability of Green and Seasoned Lumber

Opinions of wood users have always differed as to the comparative durability of untreated green and seasoned timbers when used for poles, posts, or ties. Recent experiments conducted by the Forest Products Laboratory indicate that there is practically no difference in the relative durability of untreated green and seasoned timbers when exposed to the weather and in contact with the ground.

The following service records of ties laid by the laboratory in co-operation with the Northern Pacific Ry. bear out this conclusion:

LIFE OF GREEN AND SEASONED TIES.

Place.	Species.	Green or Seasoned	Average life in years.
Maywood, Wash....	Douglas Fir	Green	7.7
	Douglas Fir	Seasoned	7.8
Plains, Mont.	Douglas Fir	Green	7.6
	Douglas Fir	Seasoned	7.7
	Western larch	Green	7.3
	Western larch	Seasoned	7.4

In each of these cases the average life of seasoned ties was only one-tenth of a year longer than that of the green ties. This difference is obviously so slight as to be negligible.

Periodical measurements on poles made by the laboratory in co-operation with the American Telephone & Telegraph Co. show that the rate of decay in green poles is a trifle less than in seasoned poles.

The fact that green and seasoned timber have the same durability when used in exposed places is easily explained. Moisture content is the principal factor in determining the rate of decay of a stick of timber. As soon as the timber is placed it begins to take up or give off moisture, according to its condition of seasoning and the conditions of exposure. Within a relatively short time in exposed construction both green and seasoned timber reach the same moisture content.

When used in buildings, however, wood does not usually dry out rapidly after being placed. Wood for interior construction must be seasoned before use; otherwise it is likely not only to shrink to a serious extent but also to decay before it seasons. Very expensive building repairs have been necessitated by the use of green timber.

1-Man Grading Outfit Moves 200 Cu. Yd. Per Day.—In constructing the Federal aid roads from Columbus to Norfolk, Neb., a 2-mile section of the rough grading in sandy soil was sub-let to a 1-man outfit. His equipment consisted of a farm plow, a fresno and four horses. The last 6 days on the work he rough graded 1,400 ft. of road, requiring the moving of 1,200 cu. yd. This is an average of 200 cu. yd. per day, which at 30 ct. per cu. yd. gave the sub-contractor an excellent day's wage.

Method of Constructing Macadam in Province of Quebec

Since 1913 the Province of Quebec has been macadamizing the rural roads at a rate of approximately 400 miles per annum. At the present time the Province has approximately 2,500 miles of macadam and gravel roads. In a paper presented at the recent convention of the Canadian Good Roads Association Mr. A. Paradis, Assistant Engineer, Provincial Department of Public Roads, gives an interesting description of the methods that are employed in the construction of these roads. An abstract of the paper follows:

Climatic conditions and the nature of available material in Quebec differ so widely from those of Europe, that although European countries are ahead of us in road building, we cannot follow here the methods currently used in France and England. Even among American and Canadian engineers we find quite a diversity of opinion on this subject. This is quite natural, as we cannot suppose that speaking from personal experience the New York engineer will have the same ideas as the man who has been building roads around Lake St. John. This is due, of course, to sub-soil conditions. The autumn rains and the intense colds following thereafter, place the Province of Quebec in an unique position which cannot even be compared with that of the states of Vermont and New York close by.

The Quebec Problems.—Quebec roads must be studied, free from all theories obtaining in other countries. The special conditions found in this province are: Firstly, the heavy winter frosts which penetrate several feet into the earth and cause heaving. Secondly, the nature of the materials to be found locally and which must be used to the best advantage. Waterbound macadam, having relatively little elasticity and small resistance to shearing stresses, suffers considerably from the disturbances caused by frosts. The only way to obviate, to a certain extent, this disintegration is to keep away from the roads the water resulting from the autumn rains.

Drainage, therefore, plays a very important part in this work and neglect of ditches and gutters will entail much more serious consequences than is generally known. However, in a good many cases the drainage is not sufficient to prevent infiltration, and in these cases means must be taken to catch the water before it penetrates under the road. Water penetrates through the shoulders from ditches when their grade is poor, and even sometimes from the surrounding land, especially in cuts.

The construction of a longitudinal drain below the foundation will intercept the water and maintain the road in a sufficiently dry state, and so nullify the action of frost. The cost of these drains put down after the method adopted by the Department of Roads of Quebec is approximately 25 ct. per lineal foot, and increases the cost of construction of macadam roads approximately 10 or 15 per cent for a drain on one side only. This relatively high cost is probably the reason that drainage has not been more extensively adopted in municipal road work. It is, however, recognized that under the very unfavorable circumstances, drainage must be used to avoid the necessity of reconstructing the macadam surface every spring.

Road Metal.—Field stone is most usually employed in the construction of waterbound macadam in Quebec. Quarries are not usually sufficiently scattered, and the cost of transportation is, as a result, too high to permit the use of quarry stone on road construction in all parts of the province. Besides, nearly all the quarries produce limestone. These limestones are homogeneous and free from defects and mesh very well, but experience seems to show that they are not sufficiently hard for the necessary resistance to wear for heavy traffic. However, for roads of purely local importance, these limestones should be used wherever their cost is comparable to that of field stone.

Despite the advantage of limestone, it can be foreseen that field stone will be mostly used in macadam roads. It can be found anywhere, and the use of it for road work enables the farmers to get rid of the rock heaps often to be found in their fields, which interfere with ploughing and harvesting. Field stone, as a result, is a mixture of different crystalized blocks, with granite and gneiss predominating. It is usually hard but somewhat brittle, and almost entirely lacking in the mesh qualities which characterize limestone and schist.

It would be difficult to make a careful choice of the various kinds of field stones scattered in small heaps in various farms, and in order to lower the cost of transportation, the best procedure is to use stone close to the road. Stone which is evidently of an inferior quality can be discarded before crushing. The discard will usually be small and comprise only stone too soft to be used for the wearing surface.

It is to be hoped that the installation in the various municipalities of permanent up-keep gangs and foremen will enable this selection of stone to be made in the winter.

Hand and Machine Crushing.—The European procedure cannot in every case be applied to Canadian roads. In France the abundance and low cost of labor enable the crushing to be done by hand, at least for the surface course. They attain in this manner carefully selected stone, practically cubical in shape, and varying in size only from 1½ in. to 2½ in. This country is young, labor is scarce and consequently to be spared whenever possible. We must therefore substitute machines. Even with the high salaries latterly paid, the cost of crushing has hardly exceeded 50 ct. per cubic yard.

We must calculate therefore on the principle that we must make the best of the situation as we find it, as the aim is to better the crushing and so to grade and crush stone as to introduce here, as much as they may be applicable under our conditions, the processes which experience has proven to be most efficient in other countries.

The three principal points to be carefully watched in crushing are the speed of the machines, the renewing of worn-out jaws, and a proper arrangement of screens for grading. It is easily seen that speeding up the crushers means that stone crushed to the proper size in the upper end of the jaw will be crushed once again before getting out of the bottom, and this will result in too many small fragments. It is therefore necessary to choose a crushing speed which will prevent this, and will at the same time be sufficiently fast to give an economical output. The high price of jaw blades, which has become exhorbitant in the last year, has resulted in the use of worn jaws by some contractors and foremen until the jaws are perfectly smooth. Flat stones can therefore pass through the crusher and make their way to the screen in sizes which cannot be used.

It is essential that jaw blades be carefully inspected, and a good foreman will not await orders of the engineers to replace these when they are worn out.

Size of Broken Stone.—Careful attention to the first two points will practically eliminate the third. It can easily be seen that by diminishing the proportion of small pieces, narrower limits as to size can be set down, and we would thus use for the wearing surface nothing but stones from 1½ to 2½ in. This can only be done provided that there is not too much reject and that the small stones from ¾ to 1½ in. will prevail only in sufficient quantity to be used up as filling material in the foundation courses.

The undesirability of small stones is very apparent when one knows how difficult it is to maintain a good bond on roads macadamized with field stone. It is easily seen that the force exerted in macadam surfaces by passing vehicles is the resultant of two forces, one (vertical) being the weight of the load, the second (horizontal) being the tractive effort of the vehicle. These two forces are very variable. In the case of an automobile traveling at high speed, the horizontal force becomes very high and tears out the stone and destroys the bond of the surface. In the case of a steam roller, the vertical force is much more apparent and therefore the roller is employed to rebuild the surface which the horizontal force destroys.

It is out of the question to restrict the speed of automobiles to a point where they will not be harmful. The only solution is to offer to the pneumatic tire the solid surface with not only the necessary hardness but also the necessary weight and tensile strength.

The larger the stones composing the surface, the better the contact with adjoining stones and the more the macadam will be compact and massive. The means mentioned above for reducing the proportion of small stones, will help considerably towards the desired result. The limit as to the size of stone which will permit a sufficiently smooth surface for present vehicles is approximately 2½ in.

Limestone Dust as Binder.—Another method of lengthening the life of macadam and at the same time diminishing the up-keep cost of field stone macadam, is to use limestone dust as a binder.

There is in the Parish of St. Jean-Chrysostome, in Chateauguay County, a road built in 1913 with field stone and a limestone dust binder. This road has carried continually very heavy traffic, and in addition carries the transportation of stone for the construction of surrounding roads. In 1918, after 5 years of continuous service, there were no apparent ruts and no loose stones, although the crown of the road has almost entirely disappeared through wear.

The value of a limestone binder in connection with field stone is pretty generally recognized, but fear is often expressed that the advantage to be obtained will not be proportional to the extra expense due to the purchase and transportation, often for long distances by rail, of this limestone dust, which cannot be obtained outside of quarries. If we take it that the quantity necessary for good results is equivalent to a layer ¾ in. thick, the necessary quantity for one mile of 12 ft. road would be 146.6 cu. yd., and as we may reasonably suppose an average cost of $3 a yard, the cost of the road would be enhanced by $440 a mile, which is an increase of 6.3 per cent in the cost of a road costing $7,000 per mile.

If we now take it that by the use of this process we succeed in lengthening by 20 per cent the life of the macadam, it will be economical to use this dust. We see in this way that the reduction in up-keep cost would more than cover the interest on the additional capital used up in the construction.

Limestone quarries are unable to furnish in large quantities this binder, which consists of particles varying from ½-in. to the finest dust. In some parts of the province this dust may be obtained in its natural state. The binder which was used on the above-mentioned road in St. Jean-Chrysostome, was found right in the parish and so close to the road itself as to be quite economical.

Mistakes in Construction.—Certain foremen and contractors have the habit of considering in every case crusher dust as a binder. This error is due to a false idea of what takes place in the interior of the macadam during rolling. Under the pressure of the roller, the stones mesh themselves as to produce strong friction between the surfaces in contact. This friction produces a very fine dust which is the best possible binder when the stone possesses binding qualities. This binder will be very efficient if sprinkling takes place at the same time.

Stone which will not bind without previously filling the voids will not bind any better with its own dust. In filling the voids with dust before rolling, one may obtain a macadam with an apparently compact and even surface but which will disintegrate in a few dry days. However small the proportion of binder in the stone, the macadam must be watered and rolled, but never rolled dry until the macadam is very compact and the voids reduced to a minimum. This is the time to spread crusher dust to fill what voids may remain, and thus render the surface still more compact and sufficiently impervious to water. We must, however, make one exception. This is when limestone dust is used as a binder. Limestone must be applied in successive very small amounts as soon as the rolling begins in order to enable the limestone dust to penetrate gradually between the stones. This operation must be watched in order to prevent the application of an excessive dust at the beginning of the rolling.

We witnessed some years ago a typical case showing the undesirability of an excessive dust in the macadam. A contractor in perfectly good faith had gotten the habit of placing all the crusher dust, including the small fragments up to ¾-in., in the last layer of stone. In order better to obtain this result, the dust was spread before any rolling over the stone, which was entirely covered. Be it noted that the stone was of good quality and contained sufficient binder to give results. Nevertheless, it was only after prolonged rolling, renewed at intervals after several weeks, that he was able to obtain a satisfactory bond. One could, however, see at the same place a piece of macadam built the previous year in the same fashion, which showed a rough and uneven structure which could not be charged to wear, age or heavy traffic.

One might claim to upset this principle by showing a new macadam built after this style and sufficiently bonded. This would merely show that the stone employed was very easily bonded, and in any case the argument would only last for the time necessary for traffic and wind to destroy the layer of dust with which the surface of the macadam is camouflaged.

Another very common error in construction consists of carrying sprinkling water a considerable distance in the sprinkler itself. This means that sprinkling is interrupted for considerable intervals, during which the rolling continues under unfavorable conditions. We must not forget that the water is one of the principal materials in the construction of macadam, and although it may be true that certain limestones bind fairly well when dry, it is also true that this bond will be much more effective if treated with water at the proper time and in sufficient quantities.

It has often been noticed that in clay regions the surface of a macadam road is deteriorated for 200 or 300 ft. at each end by the clay which the wheels of vehicles spread on it. This defect which everybody sees and which is considered almost inevitable, could be much diminished by proper precautions and principally by ending the macadam with special care. Last year there was to be seen in the Parish of St. Malachie, in Dorchester County, a macadam two years old which had kept its shape and surface without any deterioration up to the point where it joined a clay road.

Maintenance of Macadam.—The up-keep of macadam roads in Quebec began two years ago, when the first signs of deterioration and of wear appeared in the roads constructed in 1912 and 1913. Two years are very short to study a problem which can only be solved through experience. It is not easy to obtain at the present time a general rule which will apply to the special conditions in our province. There are, however, certain causes of deterioration of macadam which leave no doubt as to the best measures to retard and nullify their effects.

Frost, for example, disintegrates more or less all macadam roads. This is not surprising, since the effect of frost can be seen even on solid roads. We can, therefore, adopt the practice of rolling anew every road each spring as soon as the frost has disappeared. We must not forget that this rolling must be preceded by the ordinary sprinkling. Sometimes the sprinkling may be avoided if the weather is rainy at the beginning of the summer, but it is not advisable to delay this work too long awaiting rain. The cost of rolling and sprinkling might reach approximately $100 a mile per year.

The heaving of the soil produces blisters which are a cause of rapid deterioration. These can be eliminated by drainage. If the system of drainage employed during the construction of the road has been insufficient to keep the road from infiltration, some means will have to be devised to eliminate water from the affected spots. Tile drains are usually advisable in these cases.

The cleaning out of the ditches and curbs is imperative each year and should be done in the first days of spring, before vegetation gets a chance to take root. In flat country macadam surfaces are damaged by the melting of the snows. It is impossible to hasten drainage in this territory, where the land has practically no slope.

It has been suggested that in the most exposed places, the surface should be rebuilt with a bituminous binder. Where the water crosses the road with a strong current, a local concrete pavement is usually recommended. There are, however, a number of places where the erosion is purely accidental, and in these places it is sufficient to repair the macadam surface in the ordinary way.

We must carefully distinguish between disintergration of macadam and wear. The wear is natural and unavoidable, otherwise we would have roads with permanent surfaces, which is an impossibility. It is therefore not always wise to undertake repairs at the first sign of wear on macadam. At other times, on the other hand, wear can be retarded and life lengthened by the application of certain materials such as bituminous binders, asphaltic oils or even a thin layer of fine, hard gravel. This last proposition especially provides an economical cure for rough surfaces.

Cold Weather Concrete Pavement Construction.—Our attention has been called to an error in the article "Precautions for Concrete Pavement Construction in Cold Weather" in our issue of Nov. 5. Under the section on page 540, headed "Use of Chemicals to Accelerate Hardening of Concrete," in the second paragraph occurs the sentence. "When the proper mixing water ratio of more than 5½ to 6 gal. of water is used for each sack of cement, etc." This text was incorrect in the original bulletin from which we took the material. The sentence should read as follows: "When the proper mixing water ratio of not more than 5½ to 6 gal. of water is used for each sack of cement, etc."

Types of Surfacing for Light and Medium Traffic Roads

Interesting information on gravel and sand clay types of surfacing as used in Minnesota was given by Mr. C. L. Motl, County Engineer, of Brainerd, Minn., in a paper presented at the last annual convention of the Minnesota Surveyors and Engineers Society. The paper, in abstract, follows:

Throughout Minnesota, perhaps 95 per cent of the subgrade materials are either heavy clay or black loam, as the one extreme, through various intermixtures and proportions with sand, to loose sand as the other extreme.

The chief objectionable characteristic of heavy soil is mud, or in other words, the effect of too much moisture, which destroys the foundation. The chief objectionable characteristic to sandy soil is loose sand, causing instability of roadway. Here, however, we find moisture to be beneficial. The objectionable characteristics of the intermediate mixtures are probably proportional to their relations to the extremes. Some mixtures are found that make a natural road, hard to improve upon outside of wearing qualities.

The object of surfacing is to protect or reinforce the subgrade against its weaknesses. In heavy soil this means principally protection against water, or neutralizing the effects of water. In sandy soil this means providing a foundation suitable to carry traffic under all weather conditions. In some soil mixtures it means simply placing a suitable covering coat. In other soil mixtures it may be found that the surfacing proposed will not improve the natural subgrade and should be omitted.

It is readily seen that the lighter the type of surfacing proposed the more important it is to know what is in the subgrade. This is especially true where there is a choice of materials to be used, with an opportunity to vary the composition placed. In every surfacing project an attempt should therefore be made to determine the reasons for surfacing, and estimate the quality of materials to be used. Having investigated the reasons for surface construction, and having estimated the quality of materials necessary, the next step is to locate and select those materials.

Where local sources of supply are wanted they can generally be located by knowledge of vegetation growing over them; by samples brought up by animals burrowing into them; by comparing the geological formation with places of known deposits; by inquiring from local people, etc. In sandy countries, materials suitable for road surfacing, if near the surface, usually carry a heavier growth of vegetation than the surrounding soil. In heavy soil localities materials suitable for surfacing are apt to be less productive of vegetation than the rest of the land. In addition to this there are certain kinds of vegetation that grow over the materials sought, depending upon the locality. To the experienced investigator these indications are the quickest and most productive of results. When a body of surfacing is located, its quality and volume should be determined by soundings and measurements, otherwise the available supply may often be overestimated.

The search for road surfacing material should be ceaseless. New supplies are being continually found in places thoroughly decided upon as being hopeless. Materials are being hauled long distances while undiscovered deposits may be waiting close at hand. The finding of these deposits is of as much importance to highway construction as is the use of them. The selection of materials from local sources is usually a problem of using the best out of each pit found, rather than choosing between various pits.

The material to be used, especially in light type surfacing, depends considerably upon the nature of the subgrade materials. In construction for light traffic for heavy soils, a coarse, sharp sand or gravel applied in thin layers gives good results. Fine or inert sand should not be used as it seems to make heavy soils more penetrable by moisture. For sandy subgrade a heavy sand clay is the best to use for intermixture. It appears to disintegrate and mix in with the sand and bind it up for a good foundation. Pure or ball clay is very slow to mix with sand and as a whole is not successful, especially in the light sands. Where the subgrade is light inert sand, surfacing under class one should not be attempted as the inert sand makes a poor roadway even in composition with clay soils. It has little resistance to moisture and is a poor wearing material.

In construction for medium traffic over heavy soil subgrades, good self-binding gravel is, of course, the best. This is seldom available and generally some binding material must be added. A good sand clay, or a weathered pure clay that will powder up fine when dry, seems to give the best results.

The proportion of binding material should be made as small as possible, especially over heavy soils. As the sand proportion in the subgrade material increases the binder content can be increased. Over sand clay subgrades a light coat of coarse sand or gravel is often the only surfacing necessary to give a good roadway. Over loose sand subgrades, where a foundation as well as wearing surface is necessary, a good sand clay base, with gravel wearing coat, seems to give the best results. Where gravel is not available the sand clay will give good results; and where the sand clay is not available, gravel with a high content of binder will give good results. Where a good quality of neither the above materials is available, sandy surface soil will often make a fine road over sand, especially if applied during a wet season, where it has an opportunity to compact before getting worked into the subgrade.

In applying the surfacing, no definite standards have as yet been established. The size of the job and the class of construction usually control this detail. Under class one work with heavy soils, the material may best be added in thin layers, being worked in by the traffic. Where gravel is placed on sand clay subsoil, the application can be light enough so as not to interfere with traffic, and it gradually gets packed in. There usually should be a loose layer on top during dry spells, which works in as needed during the wet weather. Where sand clay is mixed into sandy subgrades, it should be put on dry and worked into the sand with disc and harrow. Traffic should be kept off until at least one dragging is made after a good rain.

Rolling improves surface construction very much, especially if done while the materials are damp. Compacting by hauling over the deposited materials is beneficial for heavy soil subgrades; but in loose sand subgrades it may be the cause of considerable loss of material if not properly supervised. The materials should be deposited in one or two continuous winrows parallel to the center line of the road and should be spread as soon as possible after being deposited. Any delay will allow the material to settle and cause temporary, if not permanent, unevenness in the road surface. Materials deposited from equipment in motion appear to get the most uniform distribution.

The amount of material to be placed per mile must necessarily vary with the requirements of each job. In any case, it should be put on in two or three applications with the heaviest layer first and subsequent layers as needed. This makes for a better compacted surface, allows for a grading of materials, and permits the work to be reinforced where weak or irregular spots develop. Where there is some question as to the results—when materials are being applied in mixtures, such as binders with gravel, or gravel and sand over surface bases—it is often advisable to reduce the initial construction quantities, and later on add what is needed by heavy maintenance or by special construction provisions.

On solid subgrades, a blade machine can be used to good advantage in spreading surfacing. On loose sand, a heavy planer or hand work is best, as a blade machine cannot be controlled properly. Heavy equipment such as trucks, tractors and trailers, cannot be used economically where surfacing is done on loose sand or where jobs are small and widely disconnected. On heavy soil roads, with jobs of considerable magnitude, and under good management, economical results can be obtained.

Motor Truck Haulage in Sand-Clay Construction.—Eleven motor trucks are being employed in building a 10-mile section of sand-clay surfacing on Federal aid project No. 5 between Norfolk, Neb., and Columbus. The clay is loaded at the pit by means of an elevating grader into the trucks which have an hydraulic elevator for dumping. The trucks then take the clay to the road, dumping their load at the point nearest the pit first so that each succeeding load may travel over the clay and thus pack it and partly mix it with the sand. A blade grader is kept constantly on the job to keep the road smooth and passable, removing the ruts caused by the trucks.

One of the Latest Developments in Highway Grading. Fresnoes Hauled by Tractors Preparing Subgrade for the Fort to Fort Highway in Kansas. This Method Is Stated to Have Proved Highly Satisfactory Both as Regards Time Saved and the Character of Work Accomplished.

The Present Status of Impact Tests on Roadway Surfaces

By A. T. GOLDBECK,
Testing Engineer, U. S. Bureau of Public Roads.

It has been estimated that the funds available for highway construction in this country during 1920 total $633,000,000, which is more than four times the amount expended in any other previous year. It is likely that the future will show even higher figures than these and that road construction will be pushed as rapidly as road material resources, equipment, hauling facilities and labor will permit. In the face of such an enormous program it behooves us to build wisely lest we be extravagant either by too much or by too little initial expenditure for our various road systems.

Unfortunately, the necessity for such vast expenditures comes almost simultaneously with a new class of traffic which exerts a different kind of destructive effect on roads than has been exerted by traffic in the past. The heavy motor truck has transformed the road problem from one whose solution, in days gone by depended upon precedent, into an exceedingly important problem of design. We must be able to design our future roads to carry known maximum loads under known conditions of subgrade and weather, just as we are now able to design our bridge structures. We must not be satisfied with a constant cross section irrespective of subgrade conditions, but we must change the design of the road as nearly as practicable with changing conditions of subgrade. At the same time we must better sub-grade conditions by more careful drainage. Recognizing these facts, and with rational design of road surfaces as a goal, the Bureau of Public Roads has begun experiments to find out something of the fundamentals affecting road design. In a paper presented Nov. 7 before the North Atlantic Division of the National Highway Traffic Association Mr. A. T. Goldbeck, Testing Engineer of the Bureau, outlined the present status of the impact experiments. The abstract of his paper follows.

Just as in the design of a bridge structure, the design of a road requires not only a knowledge of the materials in the structure and their behavior under stress, but it also requires a knowledge of the forces acting on the structure tending to deform it out of shape. Obviously then, one of the fundamental problems is to determine just what forces are being exerted on roads tending to destroy them.

Fibre Stress in Concrete Road Slab Due to Truck Load.—Anyone who has stood on a hard road surface during the passage of a heavy truck has noticed the vibration set up in the pavement, indicating that the truck is exerting more or less of an impact action even though the surface be comparatively smooth. Such action, of course, is much accentuated after the surface becomes worn in spots or wavy and the impact then becomes very noticeable. Heavy loads at rest on road surfaces exert but little effect except on surfaces which for some reason are too soft to bear the load. Actual tests have been made on a concrete road to gain some idea of the fibre stress in the concrete directly under a heavy wheel load of a loaded truck. The indications are that when a wheel load of 8,500 lbs. is as rest on an 8-in. concrete slab laid on a rather wet clay subgrade the fibre stress in tension is only about 34 lbs. per square inch directly under the load, and since the modulus of rupture of the ordinary concrete road mixture is well over 400 lbs. per square inch, and possibly as high as 600 lbs. per square inch, the danger of serious cracking of the concrete under static loads is practically nil except at the corners of the slabs.

We must turn to impact then for an explanation of some of the past failures of road surfaces under motor truck traffic. How great can these impacts be as compared with the static weight of trucks? What impacts are likely to be exerted on road surfaces depending upon their degree of smoothness, and what effect have these impacts on different kinds and thicknesses of surface when laid on different subgrades? These are some of the questions we must answer before we can hope to design a road rationally.

The impact tests now being conducted by the Bureau of Public Roads aim to determine (1) The amount of impact delivered to road surfaces; (2) The effect of this impact on different types of surface.

Measurement of the Amount of Impact Delivered to Road Surfaces.—The method now being used for measuring the amount of impact delivered by trucks consists of delivering the impact of a moving truck to a small copper cylinder, the blow deforming the cylinder a definite amount, depending on the intensity. In these experiments, a concrete pit has been constructed in the road surface and a hydraulic jack has been placed in this pit. The plunger of the jack is enlarged at the top with a platform of suitable size for receiving the blow of one wheel of the truck. The copper cylinder which measures the blow is placed under the plunger of the jack and the blow is transmitted through the plunger to the copper cylinder. The cylinders used are turned from ½-in. copper rod and are ½ in. in length. A large number of these cylinders are prepared and are given a special heat treatment to make them uniform in their physical characteristics. A number of them are selected from each lot prepared and are subjected to pressure in a testing machine and the deformation of the cylinder is noted for each load applied. In this way it is possible to check up the uniformity of the lot of cylinders and also to determine how much load is required to deform them to a definite length. The impact deforming the copper cylinder is stated in terms of the static load required to deform it to the same length.

A little thought will show that there are a number of different ways in which impact can be delivered to a road by a motor truck and the test has been arranged to approximate these different conditions. For instance, the truck while in motion is caused to fall through definite heights striking the plunger of the jack. Again the truck is made to strike obstructions of different heights placed directly on the plunger of the jack. Several other variations of impact also have been investigated.

The speed of the truck has been made one of the variables in these investigations in order to permit of determining something of the law of the effect of speed on impact. Different sizes and makes of trucks loaded with different loads are being used. Thus far the tests have been confined to solid tired vehicles but it is the aim to extend them to an investigation of pneumatic tires and to special types of cushioned wheels and special tires. The impact of the rear of the truck only has been investigated as this impact is greater than that of the front wheels.

In the tests, a Class B, 3 to 5-ton standard army truck, a 5½-ton truck and 1½-ton truck have been used. All of these trucks were supplied by the Motor Transport Corps of the War Department.

General Discussion of Impact Pressure Tests.—Under certain conditions the impact pressure produced by heavy motor trucks is very large, the highest pressure thus far measured being in the neighborhood of 42,000 lbs. when the weight on the rear wheel causing this pressure was only 7,750 lbs. The unsprung weight on one rear wheel of this truck was 1,837 lbs. In the case of the 5½-ton truck, which has an unsprung weight of 1,000 lbs., the impact pressures produced were very much smaller than in the case of the Class B army truck. Considering a specific case, when the Class B army truck, whose total weight of 7,750 lbs. on one rear wheel, unsprung weight 1,837 lbs. on one rear wheel, fell through a height of 2 in. at a speed of 15 miles per hour, the impact pressure produced was about 34,500 lbs. In the case of the 5½-ton truck loaded with a load of 8,060 lbs. on one rear wheel, with an unsprung weight of 1,000 lbs., on one rear wheel, and under corresponding conditions of speed and height of fall, the impact pressure produced was only 23,500 lbs., or only 68 per cent of the impact pressure of the army truck. The unsprung weight of the 5½-ton truck was only 56 per cent of that of the army truck, whereas the gross load carried on the rear wheel was slightly larger in the case of the Class B truck. The indications are, therefore, that a light unsprung weight tends to lessen the impact of a truck on the road surface.

With a 1½-ton truck having a total weight of 3,470 lbs. on one rear wheel and 1,065 lbs. unsprung weight on one rear wheel, the impact pressure at a speed of 15 miles per hour and with a height of fall of 2 in. was in the vicinity of 14,000 lbs. per square inch. It will be noted that the unsprung weight of this truck is practically the same as that of the 5½-ton truck and the impact pressure produced is very much lower than in the case of the 5½-ton truck, so that it cannot be said that unsprung weight alone influences the impact pressure produced on the road but the sprung weight also exerts some influence on this pressure.

These facts are very significant for they show that the gross load of a truck is not the only factor which influences the pressure of the wheels of the truck on the road surface. It is possible to have vastly different impact pressures exerted on the road by two different trucks both having the same gross weight but having different distribution of their sprung and their unsprung weights, and when questions of road design are to be considered, the actual wheel pressure on the road is the all important thing rather than the gross load of the truck. Would it not seem logical to take these facts into consideration in framing legislation dealing with the restriction of maximum sizes of motor trucks on roads and moreover, do these facts not open the way toward a more equitable system of license fees than the more or less arbitrary systems based on gross load, carrying capacity or horse power now in use?

The effect of the speed of trucks on the amount of impact produced on road surfaces is indicated by these tests. It has been stated that the impact of vehicles on roads varies as the square of the speed but the present tests indicate that within practical speed limits this is not the case. In the results obtained thus far the impact on the road varies with some power of the speed, this power however being less than two and extending down as low as one. The persent data do not warrant a close analysis to determine this relation.

At first thought it would seem that the impact should vary directly as the height of the fall when a truck rolls off an obstruction and falls on a road surface, but these tests indicate that this is not true, the reason being that the action of the springs of the vehicle give the unsprung weight an acceleration above that due to gravity and, depending upon the spring action and upon the amount of sprung and unsprung weight, the impact effects with various heights of fall are likely to vary with different trucks. The amount of spring deflection at the instant the impact occurs is another factor influencing the amount of impact on the road.

Having determined the amount of impact exerted on surfaces by trucks under these artificial conditions, the next question arises as to what impacts are actually produced on road surfaces of different degrees of roughness. Undoubtedly the road having a rough surface will be subjected to greater impact than the smooth road and information of this character has as yet not been obtained, but it is hoped that it will be possible to obtain these results within the coming year by means of special equipment now being constructed.

What use shall be made of the results of the impact tests in the design of road surfaces? The theory for the design of beams under static loads states that the strength of the beam varies as the square of the depth and in one instance use has been made of this theory to place road surfaces of different kinds on an equal basis so far as their load carrying capacity is concerned. On the other hand, it may be shown theoretically that when loads are applied with impact on beams their strength varies directly as their depth and not as the square of the depth. With rubber tired vehicles it is a question as to whether the impact produced is of a suddenness requiring design by the latter theory, and it would seem to be reasonable that in view of the cushion effect of rubber tires the load carrying capacity of the slab will vary as some function intermediate between D and D^2. When the proper theory to use is determined, knowledge of the amount of load applied by impacts will permit of actually designing roads to properly sustain these loads.

Determination of the Effect of Impacts on Road Surfaces.—Having obtained the amount of impact exerted by trucks, the next question is that of the damaging effect of impacts on road surfaces. We are attempting to gain some information on this point through a series of tests now under way. We have constructed a number of slabs 7 ft. square laid directly on the subgrade. Half of these sections laid on a subgrade which is purposely kept wet and half of them are on a well-drained subgrade. The sections thus far constructed include concrete in depths varying from 2 in. to 10 in. and brick constructed on varying thicknesses of concrete base. Various kinds of brick have been used, including repressed, wire-cut lug and vertical fibre brick. We have used monolithic, semi-monolithic and sand cushion construction; both Portland cement grout and bituminous mastic fillers have been used. One section is laid on a bituminous mastic cushion with a bituminous mastic filler. In other sections the brick have been laid directly on the subgrade and in still others on a prepared macadam base. We are testing these slabs by means of an impact machine which is designed to represent the conditions existing on the rear wheel of a truck. This machine has an unsprung weight of 3,000 pounds and will carry a sprung weight of 9,000 pounds. These weights correspond approximately to those that would exist on the rear wheel of a 7½-ton truck. The lower end of the sprung weight is shoed with a solid rubber tire and the whole weight will be raised to a height such that when allowed to fall, the impact delivered will be one that might be delivered by a 7½-ton truck. The observations will consist of noting the behavior of the surface under repeated impacts of this machine and will also include measurements of deflection of the surface. Nothing can be said of the results at the present as the tests have not progressed to that extent. We aim to continue these investigations with bituminous surfaces laid on concrete bases using a 1:3:6 as well as a 1:1½:3 base. In addition, broken stone bases will be used under the bituminous surfaces.

With the completion of these tests it is hoped that sufficient data will have been accumulated to place the design of roads on a much sounder basis than at present and it is hoped that the results combined with the results of still other investigations will finally lead to a suitable method of determining with certainty on road types and cross-sections for definite subgrade and load conditions.

Principles of City Planning*

By NOULAN CAUCHON,
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The principal thing about town planning, at any rate one of the things that we must bear in mind—is that a city cannot live unto itself any more than can an individual. That is why we have been advocating the benefits of regional planning. The surroundings of a city are what the city depends upon; the city is merely a market of exchange; and transportation is the flux of exchange. By adopting the principle of regional planning we are endeavoring to bring about the intensive cultivation and development of land around the cities, from which the cities derive their supplies.

Now, in analyzing the town planning problem I divide it primarily into three main issues: Ethics, economics and art. These are but different manifestations of natural law, of the organic law of life.

Town Planning Fundamentally a Question of Ethics.—Ethics are those customs of righteousness which become necessity in the evolution of the race in prevailing against extermination. Ethics means the conservation of energy—above all, of human energy, the most precious of all. That is the point of view we are taking in Canada; it is the conservation of human energy, the unit of production. All wealth, after all, comes from production; it is based fundamentally upon the efficiency of the unit of production. So we are directing our efforts mainly to that organic law of life, production. We have to abolish the slum and we have to eliminate congestion for that purpose. Town planning is a gospel of social regeneration; we are looking at it altogether as a matter of sociology.

Economics are but the conversion of energy in the maintenance of life—production. Economics are but the laws of nature translated into current terms, usually into dollars and cents as the most convenient common denominator to which things different by nature can be brought to equation and solution. In other words, to engineers I may say in particular, the economics by which we compare everything by dollars and cents is, quite outside of the matter of money, the finest decimal scale that the world has ever had for a common denominator to which you can reduce things, as I have said, to an equation and solution for the conservation of energy. The values of horses differ, the values of farms differ, but when you get down to the decimal scale of dollars and cents you get a relative value for the time being; you get your scale and you get your perspective. That is why you must not think we are always thinking of money when we are giving you economic ideas.

Art is simply expression sought—I do not always say obtained—sought through the properties of mind and of matter, of truth absolute, inherent in the nature of things. Technique is but the tempered tool in master hands.

Factors in Organic Planning.—In the matter of organic planning, we are immediately concerned with two great factors, land and transportation, productivity of the soil and the trade routes. These are the two factors which from time immemorial have influenced the migration and the evolution and the revolutions of mankind. In other words, our whole hope of going on as a nation must be based upon production; where production fails you get political disintegration such as happened in the Roman Empire, and the city and country go to pieces.

Therefore, to get the finest production and the highest results we must have the highest human unit of efficiency; that is the ethics of the thing, and it is upon that that we found our endeavors in the matter of housing. That is why housing is such a very important thing in the life of the nation. It is a matter of what is due to man as his right; and as a result, the efficiency which that man and his children will attain.

Now, under the head of economics, two of the most important things we have to deal with are under the head of transportation. In other words, before you begin to replan a city, the first thing you have to deal with is the matter of your railway transportation. I have found that people almost invariably refer to the railway as a necessary evil; as something that you have to put up with. But there is no evil at all about a railway. The railway is a splendid means of transportation, both of people and of freight, at the lowest possible rate. It should seek to follow the line of least resistance, but it is not by any means an evil. I do not say that there are not evils connected with railways; sometimes they are evilly located; sometimes they are mismanaged; but fundamentally the railroad is the sinew of life and is essential to the transportation of the country.

Railway Facilities as Decorative Feature of City.—I see no reason why your railway station and your railway facilities should not be as fine a decorative feature of your city as is any other of the functions of life—for it is a function of community life; it is inherently fine and beautiful if you treat it so, if you give it proper expression.

The trouble with the railways in most of our cities in this country is that the railway got there first. In the old days property was not so valuable and the railways went where it was most convenient to go and where it was cheapest to build the road; then the cities grew up around them and eventually there came a condition of congestion.

When you are taking hold of a city and developing it and planning it for the future, you have to ascertain what is the path of least resistance in which you can put that railway, because if it is not in the right place, just to the exact measure that your city is prosperous will there be an inducement, an economic justification, for that railway leaving its bed and going, like a great stream in a deep valley, to the lowest point where the flow will be uninterrupted. The point is, that the more successful and the greater your city becomes, the greater will be the danger of the whole thing being upset because the railway is not in the right place. Town planners can see that a railroad roving around is liable to upset their best laid plans; so you have to get your transportation system settled first and foremost.

Separation of Grade Crossings.—Your next problem is that of the arterial highways. By "arterial highway" I am going to refer to highways reaching from the center of the city clear out into the surrounding country from which the city draws its supplies. We are trying to abolish that hard and fast line between the city and the country, because one merges into the other; it is the proper relation of things.

I am claiming that the arterial highway should be located and developed and maintained on the same principle as the railways, that is, on the principle of the ruling grade. Motor traffic has come to stay.

As I stated in a report which I made a short while ago in connection with the separation of grades in cities, it has been the custom when you come to apply to the Railway Commission for separation of grades, for the railway to state: "Our grade is so and so," 0.5, 0.6 or 1 per cent as the case may be. "Of course, in the separation of grades with the street you cannot depreciate the railway grade because if you do you affect the haulage capacity of the railway"; and invariably the highway has had to be sacrificed. Now, I maintain that neither the railway grade nor the highway grade should be sacrificed. In the separation of these grades the cost should be proportioned in accordance with the importance of the two; but the fundamental point is that the arterial highway ruling grade is just as important as the railway grade.

We have today, or we had at the close of the war, about 5,000 locomotives in Canada, which, taken at an average of about 300 hp. each, means 1,500,000 hp. We have also 250,000 motor cars on our roads, which, at the low average of 20 hp., means 5,000,000 hp. That motor traffic is going to double, treble, quadruple, within our easy knowledge; therefore you will have a horsepower of not 5,000,000, but possibly 50,000,000 in the future.

The highway traffic of Canada and of the United States is going to be a greater factor in connection with our transportation than the railway traffic, because you must recognize that everything that is carried on the railways is first carried over the highways, and an enormous amount of the stuff that is carried over the highways never reaches a railway. So your highway traffic, if you have proper roads, will eventually be greater than your railway traffic and this is a matter which will have to be taken into consideration; you will have to preserve your ruling grades for these highways the same as you do your railway grades.

We have 24,000 level crossings, in Canada, or there abouts, so we have some work cut out for us to separate these grades. They are not all equally dangerous, but the economic factor is there of separating them and at the same time protecting the grades.

There are two classes of roads, the local development and the through highway such as the Toronto and Hamilton highway. We are expecting that the Toronto and Hamilton highway will be carried through for connection between Niagara and Hamilton and then on to Brantford, London, Chatham, Windsor, Detroit and through. But if these roads are to become "through" highways, they must be dealt with on the same principle as the great railways of this country; that is to say, they must go on independent rights of way without any frontage.

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*From an address presented Oct. 17 at the Joint Conference of the American City Planning Institute and the Town Planning Institute of Canada.

The Toronto and Hamilton highway is the best example of the local development road that can be found anywhere in the country; it is fast becoming a village from one end to the other. Now that very feature of the local development is going to choke the usefulness of that road as a "through" highway. Therefore we shall have to have both; we shall have to have good local highways as well as "through."

Duplication of Railway Terminals.—One of the first things that was proposed in the planning of Ottawa, back in 1909-10, was in connection with these railways that enter the city. As is the case in many cities in the United States and Canada, we had a triplication of services; we had three railways coming into the city, each with an independent entrance. That is absolutely unnecessary. Our national waste is perhaps more in the duplication of terminals than it is in the duplication of main lines, bad as that has been. About 80 per cent of the cost of the land for a railway running, say, from Ottawa to the heart of Montreal, would be in the entrances to the two cities.

If you enter three railroads by three different entrances, you are triplicating not only the service; 160 per cent out of 300 per cent is absolute waste upon which the public have to pay interest. We have to get down to economic methods, and ont of the most economic things we can do with a view to reducing railway expenditure is to eliminate the duplication of terminals.

Terminals as a Municipal Enterprise.—In other words, the order of the future is union terminals in all cities, whether those terminals be owned by the railways or by the respective municipalities. That is what we are attempting to do at the present time in Hamilton and in London.

The city of Hamilton, as an outcome of the scheme that has been evolved there, has applied to the Ontario legislature for, and has obtained, a special Act to enable them to build the terminals of the city as a municipal enterprise. I believe that Hamilton is the first city in Canada, possibly the first in America, which has undertaken and is preparing and authorized to assume the responsibility of building terminals as a municipal enterprise. Of course, they will be leased to the railways for operation. They are awaiting the outcome of the Bill which is now before parliament providing for the taking over of the Grand Trunk Ry. System; when that is settled, the city will be enabled to deal with the companies whose rails come within the city's bounds.

Planning for Industrial Sections.—In regard to zoning, I maintain that you cannot plan except to purpose; you cannot plan unless you know what you are doing it for. If you are going to plan an industrial section, you want great broad streets, narrow sidewalks and blocks probably 500 ft. square. You have to provide for uninterrupted traffic; when 1,000 or 2,000 men suddenly come out of a factory, they simply swarm down the road, which is at peak load at certain hours. If you are going to develop a high class residential district, you want deep lots, broad frontages and boulevards; they can stand the scarrying charges of the public improvements. Then if you want a workman's industrial district, you must follow a certain plan. I am in favor of small lots and small streets, because workmen's homes cannot stand the carrying charges of a great boulevard.

This is the mistake the Germans made in their town planning. In Berlin they had magnificent boulevards and 6-story tenement houses for their workmen. Within limits these were architecturally beautiful; they were fine, costly buildings, and the effort to attain the beautiful was there and also in the broad boulevard. But the result was that these workingman had to live in 6-story tenement houses to pay the carrying charges, with as many as five courts in these great lots 500 ft. deep. Just before the war, the death rate from tuberculosis in these beautiful tenements was 2½ times as great as the death rate among the children brought up in the gutters of English towns. The explanation is very simple. Families live in two rooms. When the head of the house goes to work in the morning, he is not going to bring the children down and allow them to play where they will be run over by motor cars. The mother has to do the house work, and when the father comes home at night he is too tired and it is too late to take the children down to play. Besides, it is not satisfactory nor sanitary for a family to live in one or two rooms where they sleep, cook, eat, do the washing and everything else.

German statistics with regard to the health of the people are based on information respecting the efficiency of a man for military service at the proper age. Their statistics show that just before the war only 20 cent of the young men whose parents had been born in Berlin were fit for military service at the military age; and that was due to the condition of living which I have suggested. Moreover, it cannot be said that the German was not an orderly man; he was subjected to military training; he was amenable to rules and regulations with regard to cleanliness. There was never any suggestion that these people were not cleanly; the high death rate among these children was a result of a purely economic condition.

City Planning Simply the Technique of Sociology.—Regulations as to how high a house should be, as to how wide a house should be, as to how wide a street should be, and as to the distance between buildings—these are simply means of ensuring health; it is simply the technique of sociology, the ensuring to a man of living conditions which will give to him and to his children a degree of efficiency and a state of health that will enable him to go forward instead of backward.

Standardization of Vitrified Paving Brick

Recommendations that the brick paving specifications of the American Society of Municipal Improvements be amended so as to provide for a standard vitrified paving brick have been presented to the Brick Committee of the Society by the National Paving Brick Manufacturers' Association. The proposal, which was submitted Nov. 13 at the convention of the Society, asks for the admission of a specification providing for the standard vitrified paving brick of the National Paving Brick Manufacturers' Association as the standard of the American Society for Municipal Improvements.

This specification is as follows:

Section 1. Description: All brick shall be the Number 1 grade of standard vitrified paving brick. They shall be wire-cut and shall have square edges.

Section 2. Size: The size of standard vitrified paving brick shall be 3 by 4 by 8½ in. The width shall be .... (..) inches and the depth .... (..) inches.

Section 3. Variation in Size: Vitrified paving brick shall not vary from the standard dimensions more than ½ in. in length or more than ⅛ in. in width and depth.

Section 4. Quality: Vitrified paving brick shall be evenly burned, thoroughly annealed and uniform in texture. They shall be hard and tough. They shall show a uniform fracture when broken, free from marked lamination.

Section 5. Shape: The wearing face of the brick when laid shall be reasonably straight. Kiln marks shall not exceed ¼ in.

Section 6. Test: Brick shall not lose of their weight more than 26 per cent when tested in the standard rattler, and in accordance with the Standard Specifications for Paving Brick of the American Society for Testing Materials, Serial Designation C-7-15.

Section 7. Samples for Test: Samples for testing shall be chosen according to the Standard Specifications for Paving Brick of the American Society for Testing Materials, Serial Designation C-7-15.

Section 8. Brands: The contractor shall name the brands of standard vitrified paving brick, with the prices respectively upon which he submits bids.

Section 9. Factory Inspection: When shipments of brick to any one project, or the combined shipments to separate projects under the jurisdiction of the engineer, are sufficient to be economical, then the brick may be inspected and tested at the place of manufacture.

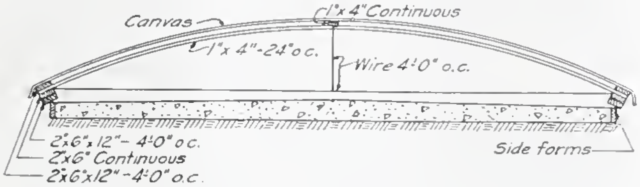
The standard vitrified paving brick is a plain wire-cut, square-edged brick. Approximately 36 brick are required for each square yard when laid flat (wearing surface 4 by 8½ in.) and 48 when laid on edge (wearing surface 3 by 8½ ins.).

Road Grade Allowed to Stand 1 Year Before Paving.—It has been found advisable in most Nebraska counties, where road paving was contemplated, to first secure federal and state aid money for the grading, and then let the road stand for one or more years in order to permit the fills settling. This insured a solid foundation for the surfacing.

Portable Frame for Canvas Covering for Concrete Road Construction

A simple portable frame for supporting the canvas covering used in concrete road construction before the earth protection is applied is described in a recent issue of The Concrete Highway Magazine. Details of the arrangement are shown in the accompanying illustrations.

A sawhorse of the required height was set up in the center of a completed section of concrete road and 1 by 4-in. transverse members laid across it. The ends were then bent down until they touched the side forms and nailed to 2 by 6-in. longitudinal runners. A 1 by 4-in. continuous strip was nailed to the truss members at the top so as to hold them rigidly and uniformly spaced.



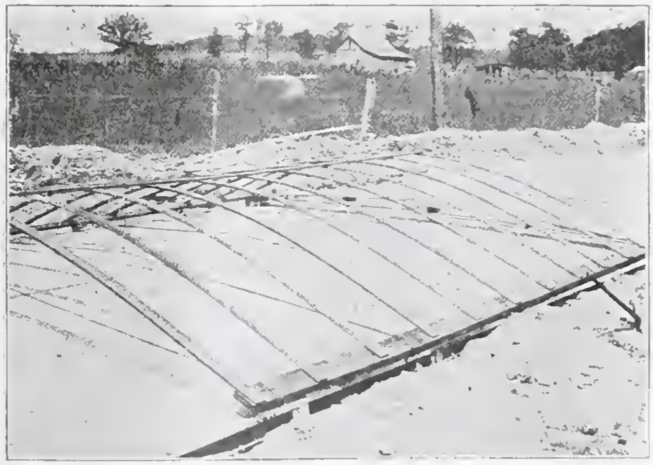
Cross Section Showing Construction of Frames and Methods of Supporting Them on Side Forms.

The lower or horizontal wire was attached to one side by winding it around a cleat securely nailed in place. In order to spring the other side into position, a crowbar was used. The wire was wrapped around a cleat and then attached to the bar, which was used as a lever until the wire was taut enough and the cleat had been nailed down. This was continued until all horizontal wires had been placed. Additional strength and rigidity were obtained by connecting the crown of the truss with the horizontal wire by a vertical wire. Cleats 2 by 6 by 12 in. were placed under the side braces at intervals of 4 ft., to facilitate handling. Eight of these supports were made in units 25 ft. long.

The cost of 200 lin. ft. of the supports was:

Lumber, 1,500 ft. B. M. at $50	$ 75.00
Wire, nails, etc	3.00
Labor, 3 men, 2 days, at $4	24.00
Total (200 lin. ft., at 51 ct.)	$102.00

The frame was devised by G. J. Lynch of Reagon & Lynch, Contractors, Uniontown, Pa., and was used on the construction of a portion of State Highway Route No. 116, near Smithfield, Pa. Mr. Lynch gives the following figures showing the cost of shifting the canvas:



25 ft. Section of Canvas Support in Position.

Eight men and one foreman working one hour were necessary to shift 200 ft. of canvas until these supporting frames had been devised. Now the same work is accomplished in 15 minutes. The covering is moved three times a day. The following table gives comparative costs between old and new methods:

Cost of shifting canvas without supports:	
8 men, 3 hours, at 40 ct.	$ 9.60
1 foreman, 3 hours, at 60 ct.	1.80
Total	$11.40
Average daily yardage	600
Unit cost per sq. yd.	1.9 ct.
Cost of shifting canvas with supports	
8 men, ¾ hour, at 40 ct.	$ 2.40
1 foreman, ¾ hour, at 50 ct.	45
Total	$ 2.85
Unit cost per sq. yd.	0.475 ct.

Paved Railroad Crossings

During the past season the county road commissioners of Wayne County, Michigan, in cooperation with a number of railroads, have been experimenting with three types of paved railroad crossings.

For light traffic railroads, street car tracks and sidings, the method consisted in digging out under the ties to a depth of 1 ft. below the bottom tie and filling in with a 1-ft. slab of concrete. Then new ties are placed and new deep rails spiked on. The job is completed by pouring concrete between the ties and over the ties to the tops of rail, joining with the concrete pavement on either side and striking off level with the tops of rail. Flange way is provided either by allowing the car wheels to form their own flange way or by placing a rail on its side against the inside of the main rail.

One railroad has been progressive enough to allow an experiment with one of its main double track lines in putting in a premolded concrete slab crossing. These slabs are approximately 2 ft. by 6 ft. long, with a depth the same as the depth of rail. They were built at Wayne in the county tile yard and hauled out to the crossing and substituted for the common plank.

The third type of crossing was similar to the first except that the surface has been filled in with special granite blocks along the inner side of the rail, which provide a flange way.

Michigan Central Crossing, With Concreted Railroad Right of Way.

Early Lettings for Wisconsin Road Work

Details of 84 Federal Aid road jobs in Wisconsin counties that will probably come up for letting in December, January and February are given in a bulletin issued Nov. 10 by the Wisconsin Highway Commission. In addition to this there will be a considerable number of large jobs of State Aid work in the various counties which have voted bond issues and which will vote bond issues during the remainder of the season. Bond issues have been voted in Rock, Green, Jefferson, Racine, Wood, Outgamie, Brown and Douglas counties to the extent of about $12,000,000, and bond issues are being discussed in Dane, Dodge, Grant, Iowa, Waukesha, Walworth, Fond du Lac, Waupaca, Portage, Waushara, Green Lake, Sheboygan, Ozaukee, and La Crosse counties to the extent of $50,000,000. This will mean there will be an attempt made to spend from $6,000,000 up of this bonded work in 1920.

Traffic Psychology.—An interesting example of so-called traffic psychology is cited by Mr. A. N. Johnson, consulting Highway Engineer of the Portland Cement Association, in the Oklahoma Highway Bulletin. On the Baltimore-Washington road there are two sections of concrete nearly adjoining and built about the same time. One of the sections was laid half width at a time; the other for the full width of 20 ft. at one time. Where the pavement was built one-half at time, there is a joint at the center plainly seen though not an expansion joint. This thin mark at the center has served to keep traffic in either direction to the right side of the road as is plainly evidenced by the two lines of oil marks, while scarcely any oil is spread over the whole width and is very noticeable at the middle of the road. This instance shows conclusively the effect upon drivers of merely a line at the center of a smooth road. Engineer Mackall of Maryland proposes to paint a stripe along the center of all sections on the Baltimore-Washington road. When the circumstance was brought to the attention of Mr. Upham, state engineer of Delaware, he decided to do the same thing on the Delaware state roads.

Changes in Wayne County Concrete Road Specifications.—Minor changes were made last season in the concrete road specifications of the County Road Commissioners of Wayne County, Michigan. The spacing of expansion joints was increased from 25 ft. to 40 ft. At the end of each day's work a 1-in. joint is now inserted in addition to the ½-in. joint at the regular 40 ft. interval.

How a Nebraska County Handles Earth Road Building

The experiences of Hall county, Nebraska, in constructing a 32¼ State and Federal Aid earth road are related as follows in a monthly report of the Nebraska Department of Public Works:

A year ago Hall county was inexperienced and without organization or equipment to undertake modern methods of road building. Today it has a very capable and experienced organization, one of which any county should be proud. It has ample equipment in excellent condition for any future county work. The organization and equipment will have cost the county by fall almost nothing except the chance plunge in accepting this state and federal aid road project at 30 ct. a cubic yard, a figure well below any that was obtained by the state then at an advertised letting.

Grading was started last fall with a crew consisting of one tractor engineer, one grader man, four teams and drivers, and the foreman who is county supervisor and appointed was road commissioner. The equipment purchased for use consisted of an Aultman Taylor 30-60 tractor, one Galion road grader, one Stroud elevating grader, two Stroud fresnos, two Stroud slips and seven Stroud dump wagons, at a total cost slightly under $6,200.

The 6 miles north of Grand Island were put to grade between Aug. 13 and Sept. 7. No back slopes were cut upon this work, consequently the grade is lower and the ditch is less deep than it otherwise would have been. More grading may be required here, but it is in good condition for traffic now, and it has been considered best not to do this work this fall. Cutting back slopes with the present heavy sod with insufficient dirt to cover the same would result in a very rough road this fall and winter. Possibly 2 miles of this road may be accepted for graveling this fall without further work.

Between Sept. 7 and Nov. 23, about 3½ miles from Grand Island west were put to grade. Nearly 3 miles of this road were all sand, so a sand-clay surface about 8 in. deep and 16 ft. wide was constructed over it. Observation this year proved that the surfacing should have extended over the entire crown. Also too much clay was placed on the surface, or rather too little sand was brought up from below and mixed with the clay, because the early summer rains produced a slippery, soft road. It is hoped to remedy this condition by adding 2 in. of gravel this fall. The road surface is very good at present.

Practically all culverts of the small circular concrete type were laid last fall. Head-walls were only completed on 16, which was very fortunate for the bridge contractor, as he is now required to remove all posts from last year's work due to insufficient reinforcement. No bridges were constructed last fall.

This opportunity should not be overlooked to state that it appears very unwise to construct small culverts ahead of the grade. This condition this year resulted in much lost time to the contractor, poorer ditch lines, more team work, shifting of many culverts, improperly located, lowering other culverts and the crushing about 80 lin. ft. of 18-in. to 30-in. pipe due to incompleted culvert filling. On the other hand, bridges not yet built prevented the proper cuts and fills, and bad looking spots in the grade resulted. All steel bridges, girders, slabs, I-beams, the larger concrete boxes, and smaller culverts under proposed heavy fills should certainly be constructed to grade ahead of the road work. Most other drainage structures in this flat level country are for purpose of equalization and could well be left until grading is completed.

The 1918 season ended with the county just a little discouraged with the result of its grading contract, because receipts did not begin to equal the expenditures. However, it did not give consideration to the facts that its organization was new and the estimates were only approximate, being about 60 per cent of the preliminary with 20 per cent of this 60 per cent retained as per contract agreement. Also, the heavy expense on sand-clay manipulation and overhaul had not yet been estimated.

The 1919 season started in April with all old equipment and in addition a new Aultman Taylor 30-60 tractor, new Adams grader and three new Stroud fresnos, representing an additional investment of less than $5,300. The crew consisted of the same foreman with two tractor engineers, two grader men, about four 4-horse teams and drivers, one plow team and driver, one sub-foreman and four laborers.

Work was opened up west of Grand Island where 1 mile of sandy loam was put to grade. From April 21 to 30, the crew moved 2,300 yd. at a cost of 20.9 ct. or approximately $230 profit. The road several miles ahead of this completed section consisted of heavy clay loam saturated with water, which, together with the frequent rains, made road construction impossible here. Consequently the entire crew moved 23 miles to Shelton at the extreme west end of the road where soil conditions made construction possible.

During the month of May the organization completed nearly 6 miles of excellent earth road. It has been impossible to approach the standard first set due to bad road conditions. Conditions were ideal in almost every particular for blade grader work this month. However, one-half the cost of construction was charged to team work. From May 1 to 30, 21,257 cu. yd. were removed at a cost of 12⅓ ct. per yd., exclusive of all equipment depreciation, but inclusive of all repairs. The county realized a profit of $3,750.

From June 1 to 30 approximately 4 miles of road were completed with total yardage of 11,616 and cost of 21 1/5 ct. or net profit to the county of approximately $1,030 Heavy team work was encountered this month which raised the yardage cost.

The month of July, 1 to 31, witnessed the completion of about 8 miles, exclusive of team work. The yardage totaled 18,935, with a cost of 9.8 ct. per cubic yard, or a net profit to the county of about $3,820. The team work before completion may perhaps double this cost per yard, but still leave the contractor, or county, clear.

Harvest and threshing took the teams from the road, causing considerable disappointment, but another month should see the team work completed. The blade grader will again go over all team work and smooth the grade.

Plan of Illinois Highway Department for Securing Early Shipment and Storage of Road Material

As a means for obtaining the shipment and storage of a large amount of aggregate during the early part of the 1920 road building season, the Division of Highways of the Illinois State Department of Public Works and Buildings has announced that it will pay for such materials as sand, gravel and stone as delivered without awaiting for them to be incorporated into the work. Vouchers will be issued direct to the railroad company for the freight and to the sand, gravel and stone producers for these materials. The same will be charged against the contractor and the amount thus paid by the department will go to reduce estimates due the contractor as such materials are used. This arrangement will apply not only to contracts now uncompleted but also to the contracts to be awarded in 1920. In order to make this effective on existing contracts, a supplemental agreement will be made by the department with the contractor and the surety company. This supplemental agreement will be forwarded to the contractor for his signature with the request that he procure the signature of the surety company at an early date.

Good Roads Conference in Wyoming.—The most important Good Roads Conference in the history of the state of Wyoming was concluded on Oct. 31st, in the forming of a permanent State Good Roads Association, which adopted a constitution, elected officers, and prepared tentative plans for the continuation of the good roads movement already under way. The avowed purpose of the association is: to co-operate with the State Highway Commissioin for the development of a comprehensive system of trunk lines for the commercial interests of the state, and to co-operate with the State Highway Commission and Good Roads organizations of adjoining states in the development of road connections in forming of inter-state national highways. The association perfected plans for the forming of an individual association in each county, which would be a part of the state organization, and a representative was appointed in each county to further such organization. The following officers were elected to serve for the ensuing year: L. L. Newton of Cody, President; N. A. Pearson of Sheridan, Vice-president; E. L. Emery, Cheyenne, Secretary; Oscar Nicholson, Riverton, Treasurer.

The Logical Contractor*

By WILLIAM S. WOLLNER.

A contractor was asked recently to bid upon a piece of work consisting principally of the erection of a timber truss lift bridge with the necessary foundations and approaches, the total cost of the job being estimated in the vicinity of $250,000. The job seemed a desirable one to the contractor and he carefully prepared his bid which he submitted to his bankers to learn if they would finance the work if he should be the successful bidder. The bankers referred him to their consulting engineer who requested him to leave his figures for a few days so that they might be checked. When the contractor returned for the engineer's decision he was told that while his bid had been carefully and accurately figured it would be useless for him to submit it as there was no chance of his being awarded the work.

The contractor was disappointed and proceeded to display his disappointment in an angry arraignment of the engineer, who also lost control of his temper and instead of explaining the reason for his statement remarked that he could even tell the name of the contractor to whom the work would be awarded. Upon the accuracy of his statement being questioned he named "Smith, Jones & Company" as the firm to whom the work would be awarded and showed the contractor the door. When the bids were opened it was found that Smith, Jones & Company were the lowest bidders for the job, their figure for doing the work being many thousand dollars less than that of the contractor first mentioned. This man called upon the engineer, apologized for his display of anger, and remarked that if the engineer had told him that he was upon the "inside" he would not have questioned his judgment upon his previous visit. The engineer protested that he was not on the "inside" and proceeded to explain the course of reasoning that had led him to believe that Smith, Jones & Company would be the successful bidders. His explanation ran something like this:

"In checking over the figures from which your bid was made I found that they took in every contingency that might arise; that you have very properly figured upon the safe side wherever there was a question as to what might be encountered in the course of the work. In your foundation excavation, for example, you figured the cost upon the expectation of encountering rock where there might only be mud and shale, it being of course impossible to determine this underwater condition accurately until the work was under way. Likewise, you figured upon using the extreme length of piling and upon paying the highest scale of wages.

"Another thing that I noticed was that a large proportion of your bid represented the cost of getting your outfit onto and off of the job. You have all the machinery necessary to do the work but it is located far from it and it was necessary for you to figure upon it as well as the cost of getting the equipment to the site of the job and back to the railroad.

"From your point of view you had figured the cost of the job properly. That is, you figured how much it would cost you to actually do the work under the worst conditions that might prevail, with a moderate margin for profit. Having assured myself of the accuracy of your figures from this viewpoint I proceeded to the next question—What would it cost someone else to do the work? In surveying the field I learned that Smith, Jones & Company were the logical contractors to do this work. They had done considerable work of a similar nature in the same vicinity and had in fact constructed a bridge for a railroad within a few hundred feet of the proposed structure a few years before. They did not have to back up their guess of what material would be encountered by figuring upon encountering the most difficult to handle; they knew what they would find and where they would find it. Likewise, they know almost to a foot the length of piling that would be needed.

"Then as to wages; Smith and Jones have been working in this same territory for some years and have built up an efficient organization in which they pay the prevailing scale but from which they get a much larger return in work than you or any other contractor not similarly situated could hope to get. Further, not only do they not have to pay freight on their equipment, but as it is located further up the stream that this structure is to bridge, they have merely to float it down to the site of the work at practically no expense for transportation or loading. As they have work to do in the same vicinity when the job is finished, the cost of removing their outfit will be comparatively small.

"Thus they had the advantage over you or any other contractor who might figure on doing this particular piece of work, and I was practically certain that they would be the successful bidders. Furthermore, as the logical contractors for this job it was right that the work should be theirs."

As engineers sometimes become contractors and are often called upon to pass upon the bids of contractors, either as the employe of the contractor or as the engineer of the project, it is important that they understand this theory of the logical contractor. As a contractor or a contractor's engineer he should consider his position with reference to other bidders, and determine whether he is the logical contractor, and if not, whether he is willing to cut down his bid to meet the advantage that the logical contractor possesses. As a project engineer he must be certain to see that the logical contractor is not only given the opportunity to bit but that he is urged to do so in order that the project may have the advantage of the lower bid made possible by his strategic position.

An illustration of how an engineer may reduce the cost of having work done by inducing contractors who are in a position to carry it on at a minimum cost bid for it was given in the recent letting of a county highway job. A road was to be built connecting "A" with "B," the construction cost, according to the engineer's estimate, being divided about evenly between grading and paving. The job was just about big enough to attract bidders from a reasonable distance but not big enough to absorb the cost of transporting a complete grading and paving outfit to and from the work without unduly adding to the expense of building the road. There were only two contractors in the vicinity of the work; one at "A" where he was grading the site for an industry, and the other at "B," where he was placing a concrete and asphalt surface on an old road for the State Highway Commission. Each of these contractors had a complete equipment for the work he was doing but was unprepared to do anything but that. The county ordinance under which the road work was to be done called for bids covering the entire job and it was therefore impossible for either contractor to bid for the portion of the work he was prepared to do.

Realizing that these men were the logical ones to do the work, the county engineer invited them to meet him in his office and pointed out to them the opportunity for combining their outfits and bidding jointly for the work. He pointed out to them that they had an advantage over other bidders in that their equipment was practically upon the job and that their forces were already organized to do the work. Being convinced, they followed his suggestion and filed a joint bid for the job which proved to be considerably less than any other offer and which saved the county a part of the cost of building the road.

Of course this engineer opened the way for charges of favoritism toward these particular contractors, but the fact that he was serving the best interests of his principal was sufficient reason for the course he took. It is the manner in which he handles matters of this kind that makes an engineer valuable or otherwise to his employer and indicates whether he belongs with the common run of untrained and inexperienced men or is entitled to his professional status as an engineer. The dollars and cents side of an engineer's duties may not be the most pleasant feature of his employment, but the working out of the business problems of his projects is an important part of the reason for his employment and will repay close study and attention.

Finishing Back Slopes With Mormon Scraper.—A Mormon scraper hung from a pole on a wagon is being employed with good success by Sprague & Nisely, Contractors, in finishing back slopes on Federal aid project roads near Beatrice, Neb. This method is used where the space between the top of the bank and the fence line will not permit the use of a team. The arrangement is as follows: A short pole is attached to the top of the bed of the dump wagon so that one end will extend to the side for 4 to 6 ft. as the conditions require. To the end of the pole the Mormon scraper is attached with a tongue. The scraper is fastened with a chain or a rope so that it can be manipulated at any angle. By driving along near the toe of the slope the scraper can be handled so as to smooth the slope in good shape where the ground is not too hard and the bank not higher than the top of the wagon.

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*From "The Monad."

Human Engineering*

By PROF. WALTER DILL SCOTT.

I want to discuss with you a new brand of engineers, the human engineering type. I am sure you are going to hear of him. I am sure you want to know about him. Let us consider together the duties and the principles that guide this new species of engineer. I assume that the aim of the human engineer is to provide a contented and efficient personnel to the organization for which he is the human engineer. Formerly, our emphasis was on efficient. Now, I think it is on contented. In providing contented and efficient workers this human engineer has a number of duties. I want to catalog some of them.

The Fundamental Duties of the Human Engineer.—The first and I think foremost duty is that he shall place every individual in the organization so that each individual will have the best chance to develop himself, to make the most of himself and also to render the greatest service to his employer. Formerly the emphasis was on service to the employer. I believe the modern engineer now will switch the emphasis to the individual, placing the individual where he has the best chance to develop himself. The placement of the man in the organization I put down as the first duty of the human engineer.

The second duty of the human engineer is to provide for the training of the men and women in the organization. By training I mean profiting by experience. The experience in the organization should be so adjusted, whether it be at the bench, in the office, or in the school room, that the individuals would profit most by those experiences. In our business organization we should have a better trained group tomorrow than we have today.

A third duty of the human engineer is to see that every dollar paid in wages secures one hundred cents in service. Whether the wage shall be on a salary, piece rate, or day wage, whether it shall be on bonus or profit sharing, immediate or remote, the human engineer should study the problem of the pay, of the wage, and adjust it so that it will not become a commodity thrown in the pit which causes the employers to degenerate into veritable bears and the employes into bulls.

The fourth duty of the human engineer is to provide the best possible, practicable working conditions, whether that be equipment or housing, an esprit de corps in the organization, or the removal of distractions. Whatever it may be, the creating of the conditions under which the worker can work to the greatest advantage to himself and to the employer is a problem which needs the attention of the engineer.

A fifth duty is that the human engineer should see that the appeal is made to the right motives. If we were considering an engine so complex that it might be operated by manpower or horsepower, by steam or electricity, by gas or gravitation, we would recognize the complexity and we would see the necessity of having an engineer to decide what sort and under what condition these motive powers should be utilized. The human individual is more complex, responds to more motive forces than any engine that we can conceive. In the past, historically, we appealed to fear, recently to wages, and we largely disregard the appeal to the fundamental instincts. We think if we appeal to the reason, to the possibility of gain, we have done all, but have neglected the appeals to the heart, the appeals to the sentiments, the appeals that are most significant in the life of the worker. A human engineer is needed in industry to study the motives which prompt action in the worker.

Another and last illustration of the duties of the human engineer is that of supervision. The worker must be supervised, but the engineer should see that supervision is not spying. It is helping; it is not inhibiting. It is encouraging. It is not to stop actions which are going wrong, but to stimulate actions which will be right. Supervision must take on a new attitude. It must be a new function. It must be something that the worker wants because it helps him.

I have wanted to get before you some of the duties that of necessity fall upon the human engineer. Whether he knows he is an engineer, whether he is one or a group of executives, makes no difference. The function, the duties, are those of the human engineer.

Principles the Human Engineer Should Have in Mind.—In all personal work the principle that I regard as the most significant is the realization of the fact that normal men like you differ greatly, that men are not equal, that differences are greater than any one has ever imagined they were until the discoveries of the last few decades. If American psychology stands for anything, if it has made any advance in the history of science, it is in the discovery of the profound personal differences in normal men. When you men read your morning paper you differ greatly in the rate at which you read. I assume you are all equally educated, that you have all read the same amount and yet tonight in reading your paper the fastest reader read four times as fast as the slowest reader in this room. The man who reads fast gets as much out of it as does the slowest man. Four times is well within the mark. To place a task of reading on the fast reader and to place the same task on the slow reader is an injustice to the slow reader and results in dissatisfaction and lack of accomplishment. In any task in which you men are engaged the best man is many more than four times as efficient as the poorest in this room. One man stands high, possibly, in one thing, and low in many others, and the differences, I repeat, are so great that any one interested in human engineering, in placing people, must bear them in mind. We must not lapse into the assumptions that a day's wage and a day's work are standard products, or that all the workers in the field should receive the same wages. Men are different, and in justice to the individual, in the cause of efficiency and great national progress, we should recognize it.

Second, the human engineer must remember that vocational selection, vocational guidance, placement of individuals, is a science, but not an exact science. Many people assume it is an exact science. Many people assume that they are infallible in judging men. There are many systems. Many people believe that there is an infallible system. On the other hand just as many people believe that it is all a matter of luck or chance, and that you can't tell a thing about it. The tendency is to drift to the two extremes; either that you are absolutely sure in judging men, that there is an absolutely sure system, or that there is nothing in it; 100 per cent sure, or all chance. The human engineer must recognize the fact that the truth is pretty near halfway between those two extremes; and that if he can improve his judgment and yours 3 or 4 or 5 per cent, he has done a great service to his organization.

The third guiding principle is that if we are to be human engineers we must analyze the men of our organization. It is not necessary to observe all the elements in a complex individual, but there are certain factors which we must get pretty clearly before us if we are to place men correctly. I have assumed that the factors that should be analyzed in you, and in the men you try to place, are as follows: You should know a man's history and reputation. You should, if possible, have an objective measurement of his skill or his talent. You must have a standardized subjective judgment. I will not take your time to discuss that. You must know the man's ambition, what he wants to be. Those five things are fundamental in placing men in the army, or in industry, or in any organization.

Another principle that the human engineer must be guided by is that we must have a job specification for all the positions in industry, the army or any other place. In your organization you want to see that job specifications are started. They probably are. They are being started this year in most of our big organizations. We ought to know exactly the specifications for every job, including yours. Just what are the duties and just what kind of a man is required to perform those duties. Without discussing in detail the significance of job specifications I want to lay it down as one of the fundamental principles that must be in the mind and in the practice of every human engineer.

The human engineer must have a system of finding the man he wants when he is wanted. I think primarily in terms of divisions of the army, or a camp of 45,000. I think in terms of business having from 5,000 to 60,000 men. The man you want is in the division. The man you want is in your company. Why go outside to find him? It is harder in many organizations to find the man in the company than it is to find him at the employment gate. That is all wrong. We ought to have a method in our organization of discovering talent when it is wanted. A man in your organization that has the ability, a man in your organization that has the skill, a man in your organization that has the talent, has the right to have that talent brought to the place where it can be used. I say, then, that the human engineer must have an adequate personnel file which is practicable and workable. We had one in the army. We had one for the officers, about 194,000. We had one for approximately 400,000,000 enlisted men. In several industrial organizations today, having from 5,000 to 40,000 men, personnel files are being established.

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*From an address presented at the 5th annual convention of the American Association of Engineers.

One more principle for the human engineer. He should, so far as possible, functionalize personnel. He should not allow personnel to be incidental. It was incidental in practically all organizations 10 or 20 years ago, but now it is becoming functionalized, as are finance, maintenance, sales, and purchases. It is becoming functionalized, and I assume it is never functionalized until one of the responsible executives of the organization is in charge of it. If your company regards engineering as important, it puts an executive in charge. If it regards finance as important, it puts a high grade executive in charge. If your company regards personnel as important, it puts a high grade executive in charge.

Every man is likely to be rather askew when he comes to perspective in connection with his own hobby. I assume the greatest advance, in human history has been made in physical science in the last 100 years. The great things in the business world have been in finance, in the handling of equipment, and in processes in connection with physical things. I believe in the next century the greatest advance is to be in human engineering, in giving the individual a chance, in making the most of him, and I believe that in 100 years from now we will have the best brains engaged in this task, which I regard as most important, most complex and most difficult to handle. I encourage you gentlemen who are engineers to take seriously the problem not so much of placing machines and the forces of nature as you do in placing men, and I include you, yourselves. In coming years the individual in business, the individual in industry, the individual as a great thing in America, is the topic which I hope you and I and all of us in America will appreciate, and to which we will turn our attention.

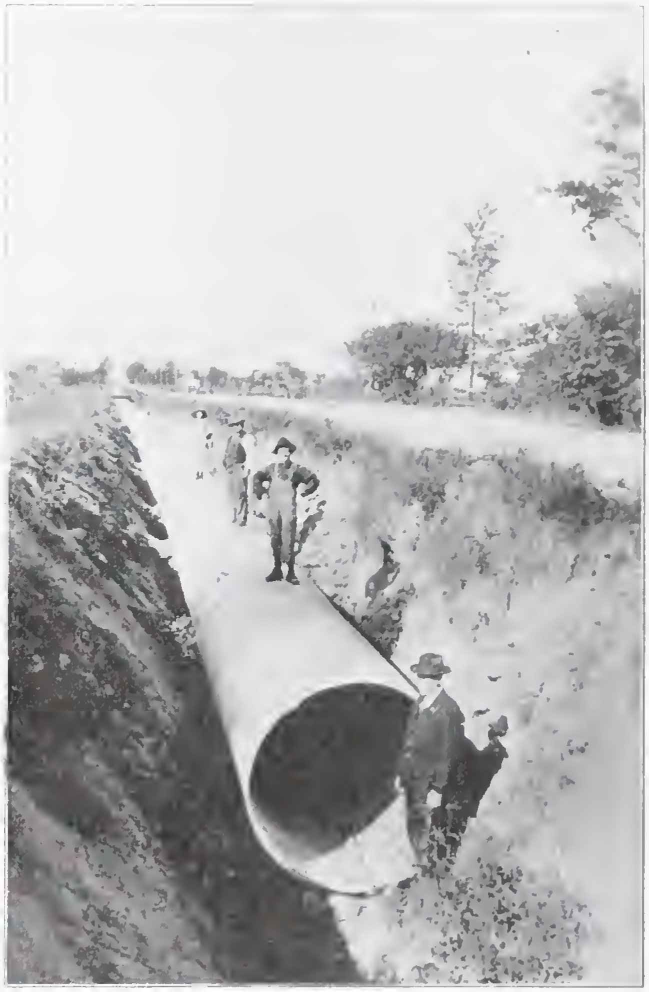
Light Weight Tractor for Road Work

A light weight tractor, equipped with crawler type wheels, that is claimed to be especially adapted for road grading and maintenance work is illustrated. The tractor weighs only 6,500 lbs. and has a tractive surface of 1,500 sq. in. The engine is of the heavy duty 4-cylinder type, with a 5-in bore, 7½ in. stroke and a speed of 750 revolutions per minute. The transmission is of the selective type sliding gear. The speed in low gear is 2½ miles; on high, 3¾ miles per hour; and on reverse 2 miles. The crawler wheels are rugged in design. The shoes, frames and wheels are of cast steel, the shoes being linked together with large steel pins, forming a flat, flexible, chain-like track 50 in. long and 15 in. wide. The tractor has a length over all of 153 in. and a wheel base of 94 in. The over all height is 96 in., and the machine width is 64 in. The tractor uses as fuel, kerosene, gasoline, naphtha, alcohol or distillates of 42° B. or higher and flash point not over 120° F. The tractor is manufactured by the Dayton-Dowd Co., 325 York St., Quincy, Ill.

Leader Crawler Tractor Pulling Road Grader.

Drainage Ditch Carried Alongside Highway in 5-ft. Pipe

A somewhat novel method was employed by the County Road Commissioners of Bay County, Michigan, for taking care of a drain of the open ditch type which extended through a cut alongside a graveled highway. The soil at this point was exceptionally soluble, causing the banks to break, thereby narrowing the roadway and at the same time filling the ditch, causing a stoppage in drainage with a result that acres of land became covered with water above this point. This particular place had been a constant source of trouble for years. The township and county officials have used wooden walls to keep the banks back but this plan proved unsatisfactory. The difficulty was overcome by the installation of 700 ft. of 5-ft. Armco iron pipe for carrying the water from the drain.



Pipe Installation at Side of Bay County (Michigan) Highway.

Order Road Materials Early

While the expenditures during 1919 for hard-surface highways, according to estimates of the Bureau of Public Roads of the United States Department of Agriculture, will set a new record with a total of $138,000,000, this figure is small in comparison with the computed available total for 1920 of $633,000,000, the spending of which promises to be dependent chiefly on the quantity of materials the present limited railway facilities can transport.

The items entering into next year's estimate are: Brought forward from unfinished work, 1919 contracts, $165,000,000; funds available from state and county taxes and Federal Aid, $273,000,000; one-fifth state and county bond issues not before available, $50,000,000; one-third unexpended balance of state and county bond issues previously available, $45,000,000;

available from new bond issues to be voted on in the fall of 1919 and spring of 1920. $100,000,000.

Unless the available open-top cars, many of which normally lie idle in the late winter, are utilized in that slack season the work which can be done will necessarily be curtailed for lack of materials. The total for 1920 is more than four times the amount that has been expended during any previous year for like purposes. Therefore there must be a tremendous increase not only in the material supplies and shipping facilities but also in the labor supply, and an enlargement of contractors' organizations. First of all, according to Thomas H. MacDonald, Chief of Bureau of Public Roads, the attention of all state, county and city road-building interests should be directed toward overcoming this car shortage. To this end it is recommended that the shipping of materials begin earlier than usual. The first step in accomplishing this, Mr. MacDonald points out, is to place under contract during December and January as great a mileage of roads as possible.

It has been customery to wait until contractors' organizations were ready to begin work before starting the shipment of material. Under these conditions many thousands of open-top cars lie idle during the latter part of February, all of March and the earlier part of April. During the past spring the number of open-top cars that were idle totaled more than 250,000. This, of course, was partly unavoidable owing to the late date at which work got under way, following the signing of the armistice. By awarding contracts as early as possible, contractors will be able to ascertain their material requirements at different points, and so will be in position to place orders dependent on rail transportation a considerable time in advance.

While the placing of material in storage, which may result from such a course, involves some expenses, it will be small compared to the loss that will result if contractors or not in a position to go ahead with the work because of lack of materials. In view of the experience of 1919 and the greatly increased program for next year, it seems probable, according to the Bureau of Public Roads, that contracts which are not awarded during the winter months will have little opportunity for being supplied with materials which require rail transportation.

Asphalt Filler for Vertical Fiber Brick Pavement*

By CLARK R. MANDIGO,

Consulting Engineer, Western Paving Brick Manufacturers' Association.

While this paper is intended as a discussion on vertical-fiber paving prick rather than on vertical-fibre brick pavements, the asphalt joint-filler almost universally used at present with this type of brick has been so interwoven with the success of vertical-fibre brick pavements, that at least a brief mention must be made of it. Four items affecting the pavement have contributed to the success of asphalt filler in brick pavements: (1) the method of application, (2) the shape and texture of the brick, (3) the quality of the filler, and (4) the changed character of traffic. Taking these items up in order, first, the bituminous filler is heated to a temperature below its flash point, is flushed over the surface of the brick pavement and squeegeed back and forth until the joints are full, leaving, necessarily, a slight surplus on the surface. It is impossible to get the joints properly filled by the old method of pouring-cans. No matter how carefully the work was done there was settlement of joints in hot weather. By flushing the hot asphalt over the brick a saving in labor is effected which more than offsets the slight additional amount of filler used. A coating of sand on the surface of the filled brick absorbs the surplus and, working into the asphalt, makes a good mastic.

In the second place, the wire-cut surface of the vertical-fiber brick which is uppermost in the pavement aids in retaining the thin asphalt mastic on the surface so that it doesn't scale off causing a dirty street. Without lugs the brick set up close and the square edges give a minimum width, even joint at the surface. The asphalt retained on the surface is only an incident to the proper filling of the joints and is not designed to be maintained. It remains, however, from 3 to 5 years and during that time acts as a reservoir for filling joints that settle, so that by the time it has worn off, all joints are packed tight with a solid asphaltic mastic.

In the third place, only the best quality of asphaltic cement is recommended as a filler, as this has proven to be the least susceptible to changes in temperature, possesses a long life, great adhesiveness, elasticity and malleability, and resists wear and rubber-tire suction. A grade of asphalt cement of about the consistency and requirements that would be specified in the best sheet asphalt pavements for an asphaltic base manufactured asphaltic cement has proven very satisfactory. Refined tar has been used in some instances, but does not at present seem to fill all the requirements.

In the fourth place, the preponderance of rubber-tired traffic on the modern pavement has practically eliminated maintenance of joints where soft filler has been used. When asphalt filler began to be used some 8 to 10 years ago, it was expected that the joints would require refilling on dense traffic streets every 5 to 7 years, but the changed traffic conditions, which have practically eliminated the horse-drawn, steel-tired vehicle and substituted the rubber-tired automobile and truck, have not made this necessary. In fact, the droppings of oil and kneading action of the tires seem to keep the filler alive and prevent any signs of disintegration, or working out of the top of the joints.

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[*] From a paper presented at the 25th Convention of the American Society for Municipal Improvement.

Registration of Engineers.—Engineering Council's committee of fifteen representative engineers from all parts of the United States has been giving careful study for many months to the matter of licensing or registering of engineers. A preliminary draft of a model law was circulated in manuscript for criticism. Up to this stage the committee's work was necessarily done by correspondence. October 13 to 17 the committee met in Chicago, and devoted five days and evenings to a thorough discussion of the information and comments collected, and the drafting of a revised form of the present model law. This revised draft has been submitted to the members of the committee for final consideration and editing. It is expected that the results of the committee's work will be presented to Engineering Council at its December meeting, and that subsequently the model law can be made known to engineers throughout the country, through the publications of the societies and the technical journals.

Personals

S. Herbert Griffith has resigned as road engineer of Talbot County, Maryland.

J. Henry Miller, a contractor, has been elected chairman of the new building code commission of Baltimore, Md.

Arthur G. McKee & Co., engineers and contractors, have moved their offices from the Rockefeller Bldg., Cleveland, O., to 2422 Euclid Ave.

A. H. Hinkle, deputy state highway commissioner of Ohio, in charge of road maintenance, has resigned to take charge of the maintenance bureau of the Indiana state highway commission.

Thomas F. Bowe, Inc., consulting engineer of New York City, have established offices in the Murrah Bldg., Columbus, Ga. The office will be under the direction of Captain Dudley Chipley, vice president.

Prof. H S. Dickerson, head of the mechanical department of the Missouri School of Mines, has resigned to accept the professorship of engineering in the Government Institute of Technology at Shanghai, China.

Alfred E. Strobel, structural engineer engaged by the engineer of buildings, C., B. & Q. R. R., on the design of the Harrison St. Freight Terminal, Chicago, will be connected with the Kniskern Construction Co., Marquette Bldg., Chicago, Ill., after Dec. 4, 1919.

Isaac C. Willis, Washington; H. A. Miller, Indiana; P. M. Jones, Nebraska; A. W. Longacre, Pennsylvania, and J. O. Wanzer, California, have sailed for Liberia to supervise the expenditure of $5,000,000 lent that country by the United States for the improvement of harbors and other public works.

E. A. Wood, resident engineer at Haskell, Tex., for the Texas Highway Commission, has been made division engineer at San Antonio, vice J. A. Block, transferred to Fort Worth to succeed W. M. A. Obenchain, division engineer, who resigned to enter private employment. Fred L. Hargett of Texarkana was appointed to succeed Wood. All are returned soldiers, Obenchain and Wood having been majors, Block a captain and Hargett a lieutenant.

G. R. Solomon and P. H. Norcross, for the past 12 years engaged in a consulting engineering practice under the firm name of the Solomen-Norcross Co., have dissolved partnership and the work of the firm will be continued under the name of P. H. Norcross, with offices at Atlanta, Ga. Colonel Solomon will remain in the Army for a short while and upon discharge hopes to return to Atlanta. The firm of Solomon, Norcross & Keis of Watervliet, N. Y., also has been dissolved, and Mr. Norcross and Mr. Keis will continue their work as consulting engineers with headquarters in Atlanta. Both of these firms were dissolved as of date of Jan. 1, 1918, at which time Colonel Gabriel R. Solomon became identified with the Construction Division of the United States Army. Certain contracts then on the books were carried to completion under the old firm names. The partnership between Colonel Solomon and Mr. Norcross was formed in 1906, and that of Solomon, Norcross & Keis in the year 1911. Between these dates and the beginning of the war the firms did work in 17 states, amounting in value to some $30,000,000, and involving every class of engineering.

Waterworks and Hydraulics Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field if subscribed for as a weekly at $3.00 a year; but anyone of the four special monthly issues may be subscribed for as a monthly at $1.00 a year (or any two monthly issues at $1.50 a year) and the 4 special quarterly issues will be sent without extra charge. Three of these special quarterly issues relate entirely to foreign engineering and construction practice and the fourth is our annual "New Equipment Issue." The *articles* in the first two issues of each month (1st and 2nd Wednesdays) completely cover the municipal engineering and contracting field. The *articles* in the first and last issues of each month (1st and 4th Wednesdays) completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and last issues of each month (3rd and 4th Wednesdays) completely cover steam and electric railway location, design and construction. See the "mast head" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging (c) Quarries and Pits
(b) Rivers and Canals (d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings (c) Harbor Structures
(b) Bridges (d) Miscellaneous Structures
(e) Properties of Materials

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The University of Texas Leads the Way in Giving a Special Short Course for Waterworks Operators

Many engineering colleges give special courses in road work for the benefit of county highway superintendents and other public servants that have not had the benefit of an engineering training. The University of Texas is about to give a short course in the chemical purification of drinking water and has invited all city waterworks men in Texas to take the course in February, free of charge.

This, we believe, is the first time that a university has undertaken to provide special training for men engaged in the operation of waterworks. We quote from a Texas newspaper:

> This course will include the chemical treatment of such water as needs this treatment, and will enable the plant operators to treat the water with their present arrangements by the latest and most sanitary methods.
>
> Letters have been sent out to the mayors and city councils throughout the state advising them of the course as planned, and urging these cities and towns to take advantage of the course by sending their operators here to take the course of instruction, and the replies to these letters that are being now received indicate that there will be a large attendance. The series of lectures will be given by experts from the university faculty and engineers of the state board of health.
>
> The winter months have been selected by the State Board of Health as being the proper time to give this course so that the operators may, by taking advantage of the instruction received, prevent the annual outbreak of typhoid fever and intestinal diseases that are transmitted through an impure water supply through the spring and summer months.

We trust that this excellent plan will be followed by every state university in America, for there is an appalling ignorance among waterworks operators, particularly in the smaller cities and villages, as to the necessity of chlorinating water to prevent typhoid and other intestinal diseases. Many of these waterworks operators are political appointees who are not given to reading articles or books relating to waterworks. We believe that the professors of engineering of the state universities can make many such men see the importance of reading engineering literature of a practical nature.

Certainly the professors of our state agricultural colleges have found it possible to develop in millions of farmers the habit of reading scientific matter relating to agriculture. This they have accomplished by going into farming districts and lecturing to farmers in such a way as to convince them that science is of much practical utility, and that any man can learn a great deal of the science that relates to his daily work if he will read the right sort of articles and books.

Among technical publishers it has long been notorious that city waterworks operators, as a class, are very poor buyers of books on wa-

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

terworks operation, and that they are not easily persuaded to subscribe for periodicals relating to their specialty. The combined membership of the American and the New England Waterworks Associations is only a small fraction of what it would be were those societies to secure as members all who would benefit thereby.

We believe that is clearly "up to" civil engineers in general and professors of civil engineering in particular, to bring about a rapid change either in the personnel or in the reading habits of many waterworks operators. If a waterworks man in a responsible position can not be persuaded to study his problems, he should be replaced by some one who will. But before discharging a waterworks superintendent, for example, an attempt should be made to interest him in the scientific management of waterworks. If, however, he persists in not keeping abreast of scientific progress in his field, he deserves no mercy. Already hundreds of thousands of lives have been lost in America because waterworks superintendents have been too ignorant to chlorinate the water, and every year thousands of additional lives are sacrificed to this inexcusable ignorance.

This must be ended within the next few years, and civil engineers must end it.

Having begun the sanitary education of waterworks operators in small cities and villages, we expect to see the professors of civil engineering undertake the task of giving economic courses to the same operator. Only a small percentage of these operators are now qualified to do their duties, economically.

Thousands of tons of coal are annually wasted in pumping city water, because those in charge are incompetent either to select or to operate the machinery. This holds true of the majority of waterworks. Similarly, other thousands of tons of coal are wasted in pumping water that should not be pumped at all. If all services were metered, water waste would be greatly reduced, but the average waterworks superintendent is either ignorant of this fact or is indifferent to it. If he is ignorant, he should be taught; and then if he remains indifferent to water waste he should be "fired."

Professors of civil engineering, it is one of your functions to "carry the message to Garcia." In this case the typical waterworks operator of the small town is Garcia, and the message is "study practical waterworks literature."

The Progressive Expansion of Stone, Iron and Soil

Although it is well known to engineers that stone expands almost as much as steel when its temperature is raised, very few know that some kinds of stone expand progressively when subjected to alternate rise and fall of temperature during a period of years. That there are stones that grow slowly larger is proved conclusively by the fact that thin vertical slabs of stone in the old tombes of the St. Louis Cemetery in New Orleans have bulged out several inches while their upper and lower ends remain in the very spots they occupied originally. We refer to the slabs on which the names of the dead are inscribed. These tombs or burial vaults are built entirely above ground, because graves cannot be dug in the water-soaked earth. Many of them are more than 150 years old. The marble inscription slabs, 1 in. to 2 in. thick and about 3 ft. long, were originally set in recesses in the masonry of the tombs. The upper and lower edges of these slabs still abut against the masonry, whereas the middle part of the slabs bows out away from the old masonry, showing that the slabs have elongated since they were put in place a century or more ago.

In St. Paul's churchyard, New York City, at the right of the church, there is an inscription slab that was originally horizontal. Its two ends rest on stones, but otherwise it is not supported. The slab is about 6 ft. long and its middle sags fully 6 in. below the level of the ends. This also is a very old stone, which, as we recall it, is about 6 in. thick and 3½ ft. wide. Evidently the slab has elongated in the course of time, and gravitation has pulled it downward during the process of elongation.

About 15 years ago it was discovered that the alternate heating and cooling of cast iron, through a wide range of temperature, causes the iron to grow larger in every direction. The editor saw a specimen of cast iron that had originally been 12 in. long and had become 16 in. long as a result of several hundred heatings and coolings. It is this progressive elongation of cast iron that causes furnace grate bars to distort if they are not free at the ends.

It is not improbable that the occasional buckling of old pavements may be due to progressive expansion, but this remains to be proved. At any rate, we have in this phenomenon of progressive expansion of certain materials under fluctuating temperature an explanation of many effects that have not been very clear. It is not improbable, for example, that the "weathering" of granite and other tough rock is largely the result of a progressive expansion of the outer parts, thus causing it to "shell off." It is certain that "Cleopatra's Needle," the Egyptian obelisk in Central Park, New York, is slowly disintegrating. When this disintegration was first observed 20 years ago, it was attributed to the freezing of water within the pores. Accordingly it was given a coat of hot paraffine. That this had been ineffective the editor pointed out a good many years ago, and he also called attention to the fact that the disintegration had been greater on the south and west faces of the obelisk than on its north and east faces. This is clearly due to the fact that the south and west faces are heated by the sun to a higher temperature than are the north and east faces. The subsequent rapid cooling of these faces during a winter night undoubtedly sets up temperature stresses which may fully account for the rapid disintegration of a stone that had endured for centuries in Egypt where great and sudden changes of temperature do not occur. But it may also be a fact that these great and sudden changes of temperature effect a progressive expansion of the "surface layer" of the stone, thus assisting the diurnal effect of temperature stress.

As is well known, earth near the surface is less dense than deeper down, other things being equal. This has been attributed to (1) frost, (2) leaching action of rain, (3) expansive force of roots, (4) the action of earth worms and other organisms, and (5) the effect of surface tension of water.

The editor has observed that small retaining walls may not be displaced appreciably for several years, and then begin to be pushed out at the top, becoming progressively more out of plumb. May not this be the effect at least in part, of the progressive expansion of the mineral components of the soil due to alternate heatings and coolings?

Depth of Frost Penetration

To the Editor: In your issue of Nov. 12, page 556, you cite instance of frost penetration of 5 ft. to 6½ ft. in Massachusetts and Connecticut during the winter of 1917-18. In Newington, N. H., during that winter I never found the ground frozen below 30 in., and it was propably colder there than it was farther south in Massachusetts and Connecticut. Quiet water in a trench, undisturbed during the winter, would probably have frozen to a depth of 6 ft. Newburyport, Mass., reports water soaked ground around a hydrant frozen to a depth of 5 ft. Frost penetration varying from 2½ to 6½ ft. in depth in New England during the same winter means nothing unless the conditions are stated in the reports.

The soil at Newington was mostly clay and the instances of examination cited were always made in newly opened trench.

WALTER S. WHEELER.

Dover, N. H.

One Man Reader for Water, Light and Gas Meters.—A plan for co-ordinating the reading of meters and distribution of bills has been suggested by Wilbur Stanfield, Commissioner of Water and Light for the city of Topeka, Kans., to the local companies furnishing light, electricity and gas. His plan calls for the employment of one meter reader for the three utilities. Twelve men at $3 each per day are now employed in this work. In addition to the saving of money in the meter reading, a co-ordinated system of bill distribution, it is believed, also would make a great saving to the city as well as to the other two companies.

A 100,000-HP. Development in Arkansas.—Engineering work is under way for a hydro-electric development on the White River in Arkansas that will provide 100,000 HP. The dam will be 240 ft. in height and 2,300 ft. in length.

A Page from Recent Waterworks Reports

Cost and Revenue of Waterworks of Providence, R. I.—The water receipts of 1918 by the Water Department of Providence, R. I., amounted to $883.752. The net cost of maintenance and operation was $429,570. The net cost of the waterworks construction from Nov. 8, 1869, to Jan. 1, 1919, was $7,819,967, upon which there has been a revenue for water sold of $22,673,411. The population of the city on Jan. 1, 1919, was estimated at 263,218, and the total population supplied (includes suburbs), 294,550.

Water Consumption at Newton, Mass.—The average daily water consumption at Newton, Mass., in 1918 was 3,420,153 gal. This amount exceeded that of any previous year and was caused in large part by the leakage from frozen and burst pipes and the running of water by consumers to prevent freezing in the first three months. The smallest consumption was 2,616,146 gal., July 14, and the largest 4,400,202 gal., June 3, with per capita use of 74 4 10 gal., as compared with 67 gal. the previous year.

1-In. Pipe Used for Temporary Water Main Extension.—During 1918 there was but little demand at Newton, Mass., either for extension of mains or for house connections, building construction being practically at a standstill. The length of main pipe added was inconsiderable with fewer new services than in any year since introduction of water. In a number of cases, instead of mains 6-in. or larger in diameter, 1 in. pipe capable of supplying two or three houses, was laid in street and this size likely will prove sufficient for some years.

Leaks in Water Mains at Providence, R. I.—On Jan. 1, 1919, the city of Providence, R. I., had 426.06 miles of cast iron pipe in its water distribution system. The number of leaks in 1918 was 47, as follows: Thirty-five in joints from unknown causes, 3 in joints caused by settling in sewer trenches, 2 in joints on railroad bridges, 4 cracked pipes, unknown causes, 1 broken pipe, unknown cause, 1 broken pipe caused by settlement, 1 plug blown out of branch, repairs costing $866.79. In addition to the above there were 200 more or less broken mains in various streets caused by frozen mains.

Cost of Icing Public Drinking Fountains.—The city of Cambridge, Mass., maintains 25 public drinking fountains. Of this number eight are ice water fountains, nine are equipped with faucets only, and eight are small "bubble" drinking fountains. The cost of furnishing the fountains with ice during the summer months for a period of 13 years, according to the annual report of the Water Board, for the ending April 1, 1918, has been as follows:

	Total cost per year, 8 fountains.	Average cost per day per fountain.
1904	$460	$1.20
1905	514	.94
*1906	795	1.57
1907	655	1.09
1908	705	1.04
1909	823	1.15
1910	712	1.24
1911	734	1.34
1912	918	1.25
†1913	970	.97
1914	747	.78
1915	719	.74
1916	623	.79
†1917	766	1.37

*Ice prices in 1906 were 25 ct. and 40 ct per 100 lb.; in other years, 12½ ct. and 15 ct. per 100 lb

†Again, in 1913 and 1917, the price of ice was 25 ct. per 100 lb.

Operations of Water Purification Plants of New Orleans in 1918.—During the year 11,854 million gallons of water were treated at the Carrollton plant and 679 million gallons at the Algiers plant. This water carried some 30,700 tons of suspended matter all of which was removed, and 6,500 tons of hardening constituents, about one half of which was removed. The increase in daily consumption at New Orleans was 10 per cent, while the daily consumption in Algiers increased 33 per cent, due mainly to war activities at the Naval Station. The average daily amount of water treated at both plants was 34.4 million gallons as against 30.9 million gallons in 1917. The gross cost of operation for 1918 was about 39 per cent higher than in 1917, while the cost per million gallons of water treated was about 26 per cent higher than in 1917. The chemical and bacterial composition of the water was approximately the same as the previous year, having only about 10 per cent higher turbidity and bacteria. Chlorine gas was used throughout the year with very satisfactory results. The cost of operating the Carrollton plant was as follows:

	Total cost.	Cost per M. G.
Labor, attendance and supervision	$36,431	$3 07
Labor (unloading, crushing and storing chemicals)	3,368	0.28
Lime	44,450	3.75
Iron	8,830	0.75
Liquid chlorine	1,271	0.11
Supplies, tools, petty cash, car fare, telephone, ice, stamps, bond premiums, etc	2,391	0.20
Machinists' labor furnished by pumping station	406	0 03
Labor and material furnished by pumping station for power, heating and lighting	2,800	0.24
Total cost of operation	$99,956	$8.43

The cost for the Algiers plant was:

	Total cost.	Cost per M. G
Labor, attendance and supervision	$11,618	$17.10
Lime	2,758	4.06
Iron	1,034	1.52
Hypochlorite of lime	219	0.32
Tools, supplies, petty cash, etc	399	0.59
Labor and material furnished by pumping station for power, heating and lighting	500	0.74
Machinists' labor furnished by pumping station	187	0.28
Total	$16,718	$24.61

Operating Results of Slow Sand Filtration Plant at Providence, R. I., in 1918.—The following tables from the annual report for 1918 of M. H. Bronsdon, City Engineer of Providence, R. I., give some results of the operation of the city filtration plant for last year:

QUANTITY OF WATER FILTERED BETWEEN SCRAPINGS IN GALLONS FOR 1918.

No. of filter.	Maximum.	Minimum.	Average.	Average maximum loss of head in feet.
1	113,790,000	24,860,000	51,590,000	4.31
2	135,960,000	29,760,000	51,770,000	4.17
3	85,070,000	27,950,000	45,810,000	4.37
4	160,110,000	24,870,000	47,080,000	4.21
5	72,500,000	25,920,000	43,740,000	4.44
6	113,770,000	29,370,000	46,030,000	4.26
7	139,600,000	28,080,000	55,160,000	4.27
8	136,750,000	29,910,000	51,940,000	4.18
9	93,860,000	26,450,000	43,200,000	4.19
10	117,150,000	29,680,000	52,310,000	4.23
Whole plant	160,110,000	24,860,000	48,570,000	4.27

OPERATION OF FILTERS IN 1918.

No. of filter.	Times scraped.	Total hours in service.	Total quantity of water filtered during the year in gallons.	Average quantity of water filtered between scrapings.	Average quantity of water filtered per day.
1	16	8,338	825,260,000	51,590,000	2,380,000
2	16	8,325	828,240,000	51,770,000	2,390,000
3	18	8,281	824,880,000	45,810,000	2,390,000
4	17	8,828	800,170,000	47,080,000	2,320,000
5	18	8,131	787,430,000	43,740,000	2,320,000
6	18	8,332	828,570,000	46,030,000	2,390,000
7	15	8,318	827,360,000	55,160,000	2,390,000
8	16	8,334	831,060,000	51,940,000	2,390,000
9	19	8,218	821,040,000	43,200,000	2,400,000
10	16	8,370	837,020,000	52,310,000	2,400,000
Total	..	.....	8,211,030,000	....	....
Av. of plant	16.9	8,292.9	....	48,570,000	2,375,000

Length of runs in days: Maximum, 69.54; minimum, 10.13; average, 20.44:

COST OF FILTERING AND PUMPING WATER AT PETTACONSET PER 1,000,000 GAL.

Year.	Pumping on to filter beds.	For cleaning beds.	Total cost per million gal. to filter water.	Pumping water to Sockanosset reservoir.	Remarks.
1907	$3.28	$4.20	$7.48	$5.63	Open beds
1908	3.48	2.03	5.51	5.03	Covered beds
1909	3.23	2.05	5.28	5.14	Covered beds
1910	3.20	1.78	4.98	4.74	Covered beds
1911	2.98	1.59	4.57	4.95	Covered beds
1912	2.72	1.56	4.28	5.05	Covered beds
1913	3.00	1.59	4.59	4.98	Covered beds
1914	3.15	1.71	4.86	4.78	Covered beds
1915	3.07	1.66	4.73	5.67	Covered beds
1916	2.79	2.13	4.92	5.40	Covered beds
1917	3.70	3.65	7.35	6.88	Covered beds
1918	3.71	3.08	6.82	8.84	Covered beds

The average color of the raw river water was 47; of filtered water 24, giving a percentage of removal of 48.9.

Cost of 595x340 Ft. Out Door Swimming Pool at Baltimore, Md.

The Clifton Park swimming pool in Baltimore, Md., is one of the largest artificial pools in the United States. It was constructed in 1915 under the plans of the engineer of the City Plant Department, which has charge of the operation of the pool. A recent issue of the official journal of the city of Baltimore gives the following information regarding the construction features and cost of the pool:

Site of Pool.—The area selected for the pool construction was triangular in shape, bounded on two sides by city streets intersecting at right angles, with a high railroad embankment, along the other side, containing about 9 acres. The construction of the highways was upon filled ground similar to the railway embankment, but of much less elevation, so that the area without drainage would have formed a natural pond or pool.

General Features of Pool.—The pool is elliptical in shape, with a maximum diameter of 595 ft. and a minimum diameter of 340 ft.

The deep water section of the pool is also elliptical in shape, with a minimum diameter of 170 ft. and a maximum diameter of 356 ft. This deep water ellipse is at one side of the pool area, and from the line of this ellipse the depth increases at a 10 per cent grade. From the shallow edge of the pool to the deep water ellipse, the grade one-half of the way is 1 per cent and for the balance of the way 1½ per cent.

The maximum depth is 9 ft. and the minimum 3 in. The pool has a capacity of 1,500,000 gal., with a water area, when filled, of 3 7/10 acres.

The water supply is obtained through the city reservoir and filtration plant from the Gunpowder River. The water is supplied through one 8-in. inlet pipe and through one needle shower with 1½-in. supply pipe. There is one outlet or drain pipe 14 in. in diameter. By regulation of inlet and drain valves there is a constant circulation of water, and the pool is emptied and cleaned annually. The city filtration is depended on for the purity of the water and chemicals are not used. Bacteriological tests of the water have never been made.

Preliminary Work. A 48-in. combination storm water sewer line from a residential section north of Clifton Park had been carried to and under the railroad embankment into the triangular area where the line was partly exposed. There was also a considerable wash from the railroad embankment, and by way of preparation for the pool construction considerable grading and filling was necessary. The cost of this work was as follows:

1,230 labor hours at 25 ct.	$1,057
356 team hire hours at 62½ ct.	222
330 ft 6-in. terra cotta pipe with fittings	69
11,727 cu. yd. of earth at 10 ct.	1,172
Total	$2,522

Plans and specifications were prepared by the Park Engineer and contract awarded by the Municipal Board of Awards at an expense of—

$ 40.00	for design
62.45	for printing
25.65	for advertising
Total $128.10	

Contract Work.—The contract work was commenced about the middle of April, 1915, and completed in 94 working days. The time allowance in the contract was 120 working days, with a bonus of $10 per day for completion in less time, so that the bonus earned was $260.

The items of work, done under contract, cost as follows:

Excavation, 4,651 cu. yd. at 35 ct.	$ 1,627
Filling and replacing, 5,888 cu. yd. at 25 ct.	1,472
Trench excavation and backfill, 1,014 lin. ft. at 45 ct.	456
10-in. vitrified pipe, 1,014 lin. ft. at 33 ct.	334
Lumber placed under drains, 410 B. M. ft. at 3 ct.	12
Concrete drain inlets, 7 at $35 each	245
Underdrains in place, 483 lin. ft. at 75 ct.	362
Concrete pit and drainage outlet	20
Changes to sewer line (including manhole)	210
Manhole for drainage valve	90
Excavation and backfill, water supply, 510 lin. ft. at 56 ct.	285
8-in. cast iron water pipe with connections, 510 lin ft. at $1.50	765
8-in. supply valve	25
Excavation and backfill for pool drain, 100 lin. ft. at 75 ct.	75
14-in. iron drain pipe with connections, 100 lin. ft. at $2.40	240
14-in. drainage valve in place	55
Lighting conduit (1½-in.) in place, 2,402 lin. ft. at 24 ct.	576
Lighting conduit (2-in.) in place, 300 lin. ft. at 27 ct.	81
Light post foundations, 7 at $24 each	158
Light post foundations, 11 at $8.50 each	93
Concrete life buoy bases, 23 at $5.40 each	124
Excavation and backfill for concrete wall alongside of pool at deepest point, 539 cu. yd. at 50 ct.	269
Concrete in wall, furnished and placed, 332 cu. yd. at $8	2,656
Steel reinforcement rods for wall and pool bottom, 68,219 lb. at 2.6 ct. per lb. in place	1,774
Wire mesh reinforcement, 15,670 sq. yd. at 8 ct.	1,253
Concrete for pool bottom in place, 1,838 cu. yd. at $5.86	10,770
Concrete walk around pool, 15,473 sq. ft. at 9.6 ct.	1,485
Overflow drains and boxes, 6 boxes, 200 lin. ft. of pipe	310
Springboards in place, 2 at $10	20
Concrete structure for sliding boards, with two concrete slides	1,125
Miscellaneous extra work	280
	$27,564

Public Artificial Outdoor Swimming Pool at Clifton Park, Baltimore, Md.

Electric Lighting and Water Supply Pipe.—Electric lighting was installed by park electrician on force account, at a cost for material and labor, as follows:

18 cast iron posts in place, $27	$ 486
3,942 lin. ft. of cable in place at 10 ct per ft.	394
18 lamps at $4.14 each	74
18 globes in place at $4 each	72
18 transformers at $0.2777 each	95
18 switches at $4.50 each	81
	$1,202

The cost of water supply, connection made by the Municipal Water Department, was as follows:

Labor	$109.73
Material	159.20
Total	$268.93

The total cost of the pool, including lighting equipment, but not including showers, diving rafts, dressing rooms or other equipment, was $31,946.

Operation of Pool.—All bathers are required to pass under showers before entering the pool, and the use of soap is strictly forbidden. The average daily attendance during 100 days of operation in 1918 was 900 persons, and the average during the first 50 days of operation in 1919, 1,400 persons. The maximum daily use of the pool in 1918 was 4,254 persons on August 6th, and in 1919 4,674 persons on July 5th. The pool is opened during the first week in June, and is continuously operated for a period of approximately 100 days.

During the winter months the pool is available for skating when ice freezes a sufficient thickness, which is very seldom.

There is a concrete pool building constructed at a cost of $45,000, in which there are four showers and 949 steel lockers of the best grade, with toilet facilities, and with ample accommodations for handling bathing suits, etc. The building contains a steam laundering and drying plant, with the most up-to-date equipment. There are two frame wing additions to the concrete building, in which there are dressing compartments and racks, in which boxes are used for checking clothing as a substitute for steel lockers. These two wings cost $10,000, and will accommodate at one time 2,400 persons or a maximum of 24,000 persons on any one day. The operating organization is under the Superintendent of Clifton Park, and the employes are classified and paid as follows:

	Per week.
1 manager	$20.00
1 engineer (laundry machine)	20.00
1 head life guard	18.00
8 life guards	16.00
8 lockermen	16.00
1 head woman attendant	14.00
1 ticket cashier	12.00
7 women helpers	10.00

The annual cost of operating the pool is something in excess of $12,000 per year. The exact cost is not known, owing to the fact that the pool has not been in operation under park management long enough to show the depreciation cost of towels and bathing suits. The receipts from the Clifton pool in 1918 (the first year of park operation) were $4,576.96, and the total patrons, not counting free entries from charitable institutions, 83,865 persons.

The Park Department has two other outdoor pools, and the number of bathers and the amounts collected at each for the season of 1919 were as follows:

1919.	Total patrons.	Total collected.
Patterson	115,428	$4,972
Clifton	118,694	7,189
Gwynn's Falls	34,616	1,582
Total for 99 days of operation	268,738	$13,743

The corresponding figures for the outdoor pool operations in 1917 and 1918 are as follows:

	Total patrons.		Total collected.	
	1917.	1918.	1917.	1918.
Patterson	138,341	113,711	$3,525	$3,574
Clifton	92,565	83,865	2,733	4,576
Gwynn's Falls	76,554	45,374	1,494	1,570
Total for 100 days of operation	307,460	242,950	$7,753	$9,721

Wrapping Garbage in Paper.—Minneapolis was probably the first city to institute wrapping of garbage. Burning has now been discontinued and pig feeding substituted, but the people continue wrapping for their own convenience, though the contractor prefers that this should not be done. Trenton, N. J., maintains the practice and finds that it increases the effective capacity of the incinerator, resulting in a saving of about 20 per cent of the coal required for burning. This is due chiefly to the absence of water from the garbage.

Clearing Land with Road Machine.—A 12-ft. blade road machine hauled by a farm traction engine was employed by a settler on the Milk River irrigation project in clearing a heavy growth of sage brush from 140 acres of land. The work was done when the ground was frozen, a condition that probably contributed to the success of the method. After the brush had been cut it was raked up into piles with a horse rake and burned. About 20 acres were cleared per day at a cost of about $4 per acre.

Irrigation Requirements of Wild Hay Meadows and Tule Lands

Few definite data have been obtainable regarding the duty of water or improvement of swamp land and wild hay meadows. These lands embrace several million acres of the intermountain great basins region. More than one-third the irrigated land in Oregon is wild meadow.

Interesting information on the irrigation of these lands is given by Prof. W. L. Powers of the Oregon Agricultural College Experiment Station in the November Reclamation Record, from which the matter following is abstracted:

A system of wild flooding has been practiced for distributing the water over the wild-hay meadows. This primitive method of irrigation has been persisted in throughout much of the area largely due to the lack of transportation, large holdings land, application of abnormally large amounts of water, and the desire to maintain a low cost of production. Improvements of these lands will necessitate levees or outlet drainage ditches in places and better storage and control of the irrigation water so that it can be applied in periods. This will make it possible to replace the wild grasses with more digestible, higer yielding, domesticated clovers and grasses and it will afford a means of controlling the alkali.

Experiment fields has been maintained in three marsh areas in south-central Oregon, and for the past four years water-variation trials have been conducted under field conditions and checked by the use of large soil tanks arranged to show the most economical yield per unit of water and the maximum yield per unit of land. The results show that an average depth of 18 in. of water on the field could produce maximum yields at present secured or a little more than the most profitable yields of hay crops on the marsh lands. The greatest yields of wild hay per acre inch have been secured frequently with a net use of 12 in. depth of water per acre. The yield per acre-inch becomes more important where water is limited and the land area available for irrigation is in excess of the water supply. In such cases it is more important to use tame grasses, which require less water per pound of dry matter produced. A small portion of these wild meadow lands can be cultivated, using hardy grain crops and row crops with some rotation, and an occasional loosening up of the soil to give a better distribution and more efficient use of the water.

The quantity of flood water pumped from two dyked tracts in Klamath ranged from none to 3½ acre-inches an acre, while the quantity pumped on for irrigation later in the season ranged from 6 to 12 acre-inches. From the quantities pumped on and off these dyked marsh areas and containing several hundred acres in each case and fairly free from subirrigation, it would seem that where some excess water is to be drawn off at the beginning of the drawing season, leaving the soil in a very moist condition, it would not be necessary to apply more than 12 acre-inches per acre as supplemental irrigation later on in the season. Under this condition a pumping plant serves a dual purpose. Some alkali is removed in this irrigation and the drainage process. The supplemental irrigation late in the season provides a favorable moisture condition for the feeding roots in the surface soil layers where the most available plant food is to be found and forces growth during the best growing weather. It also serves to some extent as a protection against fire on the peat marshes in extremely dry seasons and keeps any alkali salts distributed through the soil.

The average water cost per pound of dry matter for alsike and timothy grown on these meadows under good conditions averaged about 600 lb. per pound of dry matter, while for native or wild grasses it runs from 1,000 lb. per pound of dry matter upward. The average yield of wild hay is about ¾ ton per acre, whereas the alsike and timothy have averaged about 3 tons an acre, or have given twice the yield with about half the water commonly used on the wild hay land. In the Klamath region, about 5,000 acres of wild meadow lands have been converted to alsike and timothy and are producing twice as much forage and of a higher quality than was formerly secured.

Effect of Installation of Drainage, Sewerage and Water Purification on Community Health

The effect of the installation of sanitary utilities on community health is strikingly illustrated by a table accompanying the report of the Committee on Water Supply, submitted at the recent convention of the American Society of Municipal Improvements. The table which is reprinted below shows the experience of New Orleans following the introduction of effective drainage in 1900, of sewerage starting in 1907, and water purification in 1908.

EFFECT OF DRAINAGE AND SEWERAGE AND WATER PURIFICATION ON DEATH RATE AT NEW ORLEANS, LA.

		Percentage of premises at end of year connected with					Main drainage system.			Deaths per 100,000 per annum	
Year.	Thousands of population.	The sewers.	The new water supply.	Miles of sanitary sewers in place.	Miles of water mains.	M. G. D. consumption.	Acres area drained.	Miles of lateral storm drains, 10" to 30".	Death rate per 1,000 per annum from all causes, average.	From malaria, average.	From typhoid, average.
1881	219	..	..	...	...	....	......	...	....	...	..
1889	242	..	..	...	...	....	[5]......	...	28.6	156	21
1891	245	..	..	...	...	....	......	...	....	...	..
1899	284	..	..	...	...	....	[6].....	...	27.2	104	39
1900	287	..	..	...	...	....	[7].....	...	25.9	68	40
1901	292	..	..	...	...	....	20,000	...	22.2	40	48
1902	297	..	..	...	...	....	21,000	...	22.1	33	45
1903	302	..	..	[3]..	...	....	21,000	...	22.2	27	38
1904	307	..	..	115	...	....	21,000	...	22.2	22	36
1905	312	..	..	160	[4]..	....	22,000	...	23.5	15	32
1906	318	[1]..	..	224	35	....	22,000	...	21.4	13	30
1907	323	1	00	273	160	....	22,000	...	23.6	12	55
1908	328	5	3	202	485	....	22,000	75	22.4	20	33
1909	333	13	[2]22	322	508	....	22,000	132	20.3	13.	29
1910	339	20	38	353	512	....	22,000	154	21.4	9	32
1911	345	28	50	393	518	15.7	22,000	170	20.4	9	31
1912	352	38	65	426	530	16.6	22.000	181	20.1	8	14
1913	358	55	78	462	547	19.2	23,000	190	19.8	6	17
1914	365	67	85	477	565	22.7	24,000	233	20.3	9	21
1915	372	86	90	486	581	25.1	25,000	265	20.8	9	21
1916	378	92	93	496	591	†27.8	25,000	293	18.1	7	23
1917	384	93	94	501	591	†29.7	*28,000	303	19.6	4	23
1918	389	91	96	505	594	†33.2	*30,000	325	‡25.5	4	20

*Not including 11,000 acres agricultural land draining to Jefferson-Piaquemines Drainage Station and 7,700 acres agricultural land draining to Citrus Draining Stations.

†Water sterilized with cl.

‡Death rate per 1,000 from influenza, 4.5; death rate per 1,000 from pneumonia, 3.4; death rate per 1,000 from other causes, 17.6; total, 25.6.

[1] Started to connect.

[2] Supply of filtered water began.

[3] Started building sewers.

[4] Started laying water mains.

[5] 10,000 acres very poorly drained.

[6] 15,000 acres poorly drained.

[7] Started operating.

The results shown in the table are discussed in the report as follows:

To the end of 1899 the city of New Orleans was very poorly drained, its soil was saturated with water, and what drainage existed was entirely on the surface. In 1900 the new drainage system commenced to effect substantially the whole populated area, and there was at once a very marked and progressive decrease in the general death rate and a still more marked decrease in the death rate from malaria, but no effect on the typhoid fever death rate.

The tablulation shows the rate of utilization of the new sewerage and water supply systems in percentage of premises served from 1908 when these systems started in operation, and the progressive extension of the drainage system to eliminate soil satnration to surface or water standing on surface and to permit of the drying out of the upper soil strata in outlying areas of the city.

The combined result with all three systems shows a reduction of total death rate from 1899 to 1918, eliminating the influenza epidemic of 1918, of from 27 to about 19 per 1000; a reduction of the death rate from malaria of from 104 to 1 per 100,000, and a reduction of the typhoid death rate of from 39 to about 18 per 100,000.

All of the above figures include deaths in the Charity Hospital, a very large institution which receives patients from several states surrounding Louisiana, as well as from Louisiana and a considerable percentage of the total deaths, and probably a larger percentage of the deaths from typhoid fever, are of non-residents, at this and other city hospitals. It is a fact, however, that within the city, in deaths from residents of the city, there appears to be no evidence that the general water supply has now or ever has had any influence on the typhoid fever death rate, and it is with a view of emphasizing the necessity of guarding other sources of typhoid infection and other means of its dissemination that it is believed the experience at New Orleans is especially valuable.

Until 1912, when 38 per cent of the premises of the city were served by sewers and 65 per cent by filtered water, there was no marked decrease in typhoid death rate which averaged 39 per 100,000 for the decade ending 1899, and averaged over 37 per 100,000 to the end of 1912.

Since 1912, the average typhoid death rate has been less than 18 per 100,000, but it has averaged 22 per 100,000 during the last three years when over 90 per cent of the premises of the city were connected with the sewers and furnished with filtered water and when in addition to especially efficient filtration the water after filtration was sterilized with chlorine, whereas it only averaged 18 per 100,000 for 1912 to 1915 inclusive, where a less number of premises were served with water on sewerage facilities and when there was no sterilization of the water after filtration.

It is believed that the influences which have effected typhoid in New Orleans are: Importation of actual cases, and, the spread of this infection by means of flies or similar means.

The noticeable increase in typhoid for the 1890 decade, as above the 1880 decade, was in all probability in some degree associated with the introduction in the best sections of the city of water closets which discharge into cess-pools, which in turn often overflowed to open street gutters, being more dangerous, possibly, than the old time closed vaults which were mostly used until sewers were introduced. The water supply in those days was unfiltered from the Mississippi river and very muddy, but only about 8 per cent of the population were connected with it, and only part of those who had connections used it for drinking. The rest of the population depended for their water supply upon wooden cisterns built upon foundations well above the ground surface which caught and stored rain water from slate roofs of the houses, and there is little possibility of the contamination of such cisterns generally, if at all, with typhoid, and no evidence that the raw river water was ever so contaminated at New Orleans.

Every agency tikes to claim credit for every possible benefit toward which it contributes, but the New Orleans water and sewerage authorities do not believe that filtration of the water supply or its sterilization has been at all a factor in this direction, but rather that the elimination of vaults and especially of cess-pools receiving the flow from water closets and overflowing to open street gutters, through the substitution of sanitary sewers with an abundant water supply for the immediate removal of all contaminated matter, and the adequate cleansing of all containers and other possibly contaminated articles constitute the only factors which they have contributed toward the elimination of typhoid.

Steps in other directions, especially in action by the Board of Health authorities looking to the safeguarding of the milk and raw vegetables or other food supplies and the prevention of flies, and the more general screening of markets and houses, and finally, the searching out and remedying of local causes whenever and wherever typhoid appears, are believed to be in great measure the cause of the reduction in typhoid death rate thus far accomplished and to constitute the main hope of further reduction. Those cases which are contracted by people residing outside of the city and brought to the local hospitals, or by residents of the city while on vacation or business trips elsewhere, constitute a very large percentage of the total present typhoid fever death rate of New Orleans and the chief danger of the establishment of local foci of the disease. It appears, therefore, that the present typhoid death rate of New Orleans which has averaged about 18 per 100,000 during the last seven years ranging from 11 to 23 per 100,000 is the result of very broad surrounding conditions and of local conditions not in any way associated with the water supply and that the general lesson as to the importance of such broad surrounding and local conditions other than water supply in its bearing on the ultimate eradication of typhoid is most strongly indicated.

Use of Steam Shovel for Small Diameter Sewers

By GEORGE M. SHEPARD.

On one piece of work of which the writer has had charge this season, the contractor, rather than use hand labor, has employed a steam shovel for laying water main with 7-ft. cover, and 8-in. to 12-in. sewer for depths varying from 8 to 22 ft. The soil consisted of a loose sand with occasional layers of gravel and irregularly mixed with boulders. A slight amount of water was encountered at depths varying from 11 to 14 ft., gradually increasing to greater depths.

Two shovels with ⅞ cu. yd. buckets were used on the work. The excavation was carried to within several inches of grade and the remainder finished by hand. The material as excavated was deposited over the completed sewer in the rear of the shovel. The sides of the cut were carried up at slope that would stand without sheeting, which for the soil encountered averaged slightly less than 1:1. For depths greater than 15 ft. the lower portion was sheeted as shown.

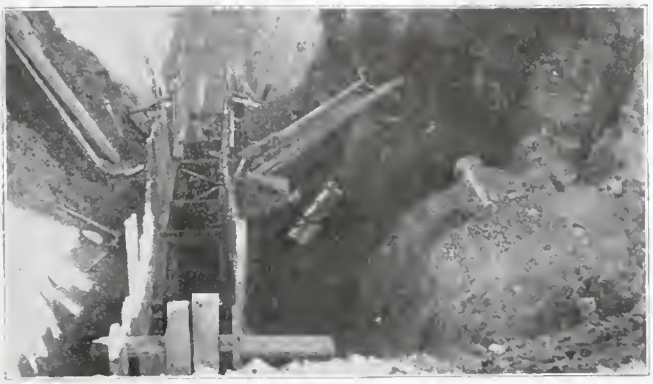


Fig. 1—Steam Shovel Excavation for Small Sewers.

From the engineering viewpoint the use of a steam shovel for small sewers is objectionable on account of the greater difficulty in setting line and grade than with ditching machine or hand work. This objection can be overcome by care and experience in the method used. For grade setting vertical bars of flat iron, ¼ in. by 2 in., are set in the ground ahead of the shovel at each 25-ft. station, so that a corresponding edge of each bar is aligned with the center line of the sewer. Short horizontal wooden strips are clamped to these bars at a fixed height above grade. The grade rod is set by sighting back over these strips, the grade being checked occasionally by instrument. Alignment is obtained from a plumb bob suspended from one of the timbers supporting the shovel and in line with the row of iron bars ahead. A further objection is that when a sewer is run down the center of a street practically the entire street is torn up and will require some time to settle. This objection is not serious, for in sandy soil where the above use of the steam shovel is best adapted, the sand is compacted when dropped from the bucket.

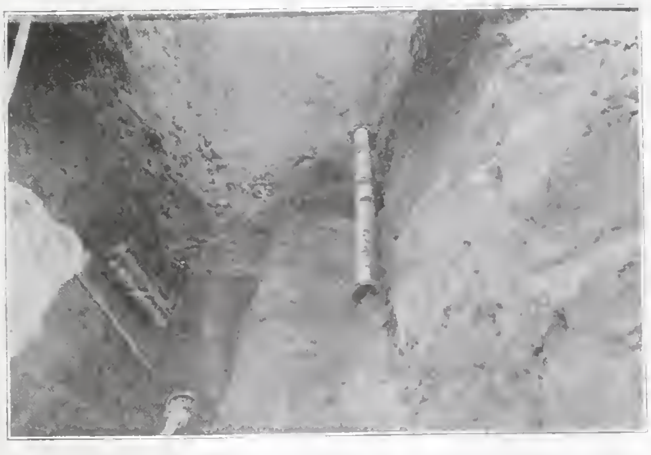


Fig. 2—Water Mains and Sewer Laid in Same Trench.

Figure 2 shows the laying of water main and sewer in the same trench, as was permitted on certain streets. This accomplished a saving for the city, as arrangements were made to deduct a considerable amount from the unit price, thus providing funds for further extensions than would have otherwise been possible.

For depths of from 18 to 22 ft. where sheeting was used for the lower 4 to 6 ft., progress was made at the rate of from 18 to 25 ft. per day of 10 hours, which of course left the shovel idle for a large portion of the time. For depths of from 9 to 12 ft. a maximum of 145 ft. of pipe daily was laid, the progress here depending on the shovel. The force required for each shovel and their wages per 10-hour day were:

One foreman	$ 7.50
One shovel man	9.00
Two pipe layers	6.50
One fireman	6.50
Two laborers	5.80
Man and team	10.00

Cost of Water Main Construction in Mason City, Ia.

In a paper presented last April before the Iowa Section of the American Water Works Association, Mr. W. A. Judd, superintendent of the Mason City Water Co., gave the following data on water main construction:

In 1915 and 1916, labor was plentiful with the Mason City Water Co. at 22½ ct. per hour. In 1917 and 1918 it was scarce at any price and part of the time the company had only its emergency crew of five men to work with. In 1915 a half-mile stretch of 10-in. pipe was laid in good clay digging, with some shale. The weather was hot and the laborers, except the pipe gang, were not working up to usual efficiency. The earth excavation costs ran up to 37 ct. per cubic yard, loose rock 88 ct., back filling 11 ct., and the 10-in pipe only cost 5 ct. per foot to lay. Part of this low laying cost is due to the fact that the ditch stood up well, and 500 or 600 ft. would be laid in one day. Contrast this laying cost with another job the same year, which was scattered in little bits for half a mile, laying intersections preparatory to paving. The laying cost here for 6-in. pipe was 7 ct. per foot, but excavation prices were lower than on the longer job, no doubt due to the cooler weather which prevailed. In 1916, one block of 10 in. pipe laid in a rock ditch a little at a time cost 16 ct. per foot with labor at 22½ ct. per hour. On this job the cost of back filling jumped to 22½ ct. due to the rock present. On another very similar job in 1915 a large amount of rock made the cost of back filling run up to 24½ ct. per cubic yard

In 1915, a string of 8-in. pipe was laid in sandy clay during hot weather. Earth excavation cost 32 ct. per cubic yard; back filling 13 ct. per cubic yard, and laying 3.7 ct. per foot. A similar job in 1916, when a new pipe gang was broken in, showed earth costs 40 cents., back filling 16 ct., and pipe laying 7.7 ct. During very hot weather, that year, a string of 8-in. pipe was laid following a trenching machine at a cost of 7.1 ct. per foot. The same pipe gang followed the same machine with a string of 10-in. pipe for 7.8 ct. per foot, and another string of 10-in. pipe, in caving clay and under rather difficult circumstances, for 8.9 ct. per foot.

The influence of weather and soil conditions is shown very well in some 6-in. jobs following this machine. One job in wet, sticky clay cost 8.9 ct. per foot. Bracing was needed here right behind the machine. Another job in wet clay but with weather conditions more favorable cost 6.4 ct. per foot, while in a good clay ditch with favorable weather the cost ran 4.0 ct. and with the best weather of all, 6-in. pipe laid in a sandy ditch only cost 3.2 ct. per foot. In 1917, with a small gang at 30 ct. per hour, earth excavation cost close to 42 and 47 ct. on two representative jobs. A little rock in one caused back filling to cost 16 ct., while the other cost 12½ ct. Pipe laying on these jobs ran about 7 ct. per foot, which was approximately the cost also of laying pipe in a rock ditch dug by contract.

In 1918 earth costs varied from 12 to 66 ct. and rock excavation in small quantities went as high as $5.50 per cubic yard. The cost of pipe laying was very consistent, however, being nearly 8½ ct. per foot for 6-in. pipe on all jobs. The old, dependable emergency gang was responsible for keeping the pipe laying price so reasonable.

Present Conditions in the Waterworks Field

In its report submitted at the recent convention of the American Society of Municipal Improvements, the Committee on Water Supply, of which Mr. Geo. G. Earl is chairman, gives an interesting summary of present conditions in the waterworks field. An abstract of the report follows:

Within the last few years all material and labor required for the construction, maintenance and operation of waterworks systems have advanced very greatly in cost; and in addition, it is the general experience that the amount of labor output per man in most occupations has decreased, all resulting in a very much higher cost per output of service than existed before the war, which has left in its wake many problems of readjustment and reorganization. These increased costs exist not only in water supply systems but in all public utilities.

Public utilities generally are a most important factor in our daily lives, ministering directly to our comfort and convenience and effecting our health. Everyone of them is essential, and rather than eliminate any of them, we could afford to pay for the services which they render a great deal more than their present cost.

Inadequate Returns for Public Utility Service.—Utility charges have not increased, because of contract or other legal limitations, or because of public opposition, in anything like the proportion that the cost of the service which they render has increased. Many of them which are privately owned are in the hands of receivers; many others are struggling for their lives, and very few of them are in a position to extend and maintain their services as they would be if they could always be assured of adequate return for the service which they render.

Years ago, public utility corporations working under franchises of various kinds were regarded as splendid investments, and companies obtaining such franchises often took advantage of their opportunities to over-capitalize such enterprises and to exploit the public, either directly in rates or indirectly by the sale of securities at fictitious values based upon the anticipation of earning power in excess of that which has finally been allowed. Because communities have retained their police powers and their taxing powers and have established authoritative bodies for the government of rates charged, and the establishment of regulation's concerning utility enterprises much hope of gross public exploitation in rates has disappeared, and capital is not now to any great extent seeking utility enterprises, since there is no longer a gambling chance of excessive profit in them, and, at present, no assurance of even a fair return. As a general thing, the bodies created for the supervision and regulation of utility enterprises intend to treat them fairly, but there are so many complicating conditions, due to existing contract rates, to franchise conditions, to valuations and taxations, and to various legal complications, and finally to a general public sentiment based on the assumption that private utility corporations have been exploiting the public, for essential readjustment to be made promptly or adequately, and even in the case of municipally owned utilities, there is always the desire on the part of the public to avoid rate increases, and because of this public desire, public authorities avoid or delay rate increases, or are forbidden by law to make them, and find themselves often in just as difficult situations as private corporations.

The fact is that neither publicly owned nor privately owned utilities can be conducted to best advantage until the public, as a whole, grasps the idea that every service must earn its cost and that the recipient of every item of service should always pay the full average cost of the items of service which he absorbs, leaving no portion of said cost to be carried by any who do not receive a service of some character from said utility. Once this idea is generally admitted, it will be easy to induce capital to invest in privately owned public utilities and to maintain them as well as publicly owned utilities up to any standard of service which the public desires and is willing to pay for.

Study Needed for Proper Classification of Service of Utilities.—Much more careful study than is usually given is needed for the proper classification of the actual items of service which utilities perform, and there is a wide scope of discretion or option as to the basis of such classifications, especially in publicly owned utilities. For instance, cities now are tending to a great scattering of population in surrounding suburbs, the cost of a water service for the well built portion of the city for adequate domestic and fire supply for its whole population will be met by a certain definite service charge per meter, and price per 1000 gal. of water supplied and tax on assessed values for surplus capacity for fire protection and increased demand, but if you extend your system to double the mileage of mains required to give adequate service to the reasonably well built portion of the city in order to give possibly one-fifth as many scattered premises the same character of domestic supply and fire protection, it is obvious that your rates per these various units must be higher for all, or else that you must have two or more rates, the one covering the actual cost for the well built sections of the city, and the others the very much higher costs, due to the scattering of population in outlying areas.

Because of the great tendency to scatter population, leaving much unused property sandwiched between occasional improved areas, the actual cost of all municipal improvements and utilities is enormously increased, and property in the well built and thoroughly served sections of many cities is allowed to depreciate in value and usefulness. More carefully and justly arranged schedules of utility rates and schemes of taxation for municipal improvements based always upon the idea that every beneficiary of every service should pay as far as possible the cost of such service, and that the service should only go to those who do pay their share of its cost, would tend strongly toward the checking of premature development of outlying and unnecessary areas, and thus allow the more consistent and thorough development of all services within such areas as are actually required for the comfortable accomodation of the whole population.

Undue Delay in Waterworks Improvements.—For several years now conditions have precluded anything more than the most essential extensions and developments of water supply systems, and today the cost of material and labor for improvements is in many cases out of all proportion to the rates which are charged for service, with the result that extensions and improvements which the growth and development of our cities really require are being unduly delayed.

Such delays often show no obvious depreciation of service up to a certain maximum demand or breaking point, and the people who are getting all the service they desire are always skeptical of the necessity for improvements, of which the plant management is painfully aware. Eventually, however, a big fire, with inadequate water supply to provide proper fire protection, or a general increase in insurance rates, or deterioration in the character of the water, because of the overload imposed upon the purification system, and possibly an outbreak of typhoid brings the public to attention, and it is found that large expenditure in improvements are a few years past due and will require that many years to complete in the face of a depreciation service due to the further increasing demand while the improvements are in progress.

Water works especially, and other public utilities as well, are essential, economical and vital factors in public comfort, well being and health that it pays to keep them up to the maximum state of efficiency which the community which they serve can afford to pay for, and that both public owned and privately owned utilities must fail in service, and eventually cease to serve at all, if they are not sufficiently compensated for the service which they render, to permit them to pay living wages to the large number of employes who are engaged in their service, to provide generally better conditions of employment and compensation for their employes than they have heretofore, and to earn their reasonable interest and depreciation and operating costs.

Efficient Public Utilities Are Vital.—Conditions since 1913 have changed enormously, a new price level has been reached and is tending toward stabilization on a much higher levle than then existed. Labor, especially, is and will remain higher; improved methods of production or building and economies or substitutions, it is reasonable to hope, will, in some degree, lower the general cost of living from its present scale, and the cost of utility development as well, but if anything is manifest, it is the common belief that the average man must, in the future, obtain a better opportunity and a better share of the comforts, luxuries and security of life for the service which he renders than heretofore, and if this is to be obtained general wages, relatively, must remain higher than heretofore. It is essential that all available human effort be devoted economically to the production, transportation and distribution of those things which we all need and desire in order that the maximum amount thereof may be available for general use. To the attainment of this end, efficient public utilities of all kinds, earning and guaranteed to each, the full cost of the adequate services which they are required to render, and paying a fair wage to those engaged in their work, are vital, and since we are a democracy in which the voice of the majority must dominate it is essential that the voice be tuned to demand a square deal all around, and nothing will tend more in that direction than a general effort to determine the actual items of service which public utilities render, and their cost, aggregating the whole cost of the service; to whom they are rendered, and see to it that every item of such service is paid for in full by its recipient. Failure to reach this result, as nearly as is humanly possible, means the exploitation of some for the benefit of others with incessant contention and a depreciated service.

Pollution of Public Supplies by Entrance of Water from Fire Protection Systems.—In Appendix 4 of the report of the Committee on Fire Protection to the American Waterworks Association at the 1919 convention of the Association, there is a summary of cases in which the public water supplies are believed to have been polluted by the entrance of water from other sources of supply, usually through fire protection systems to particular plants which have been connected with the public water supply, and also with other sources of supply, in such manner as to permit of the possibility of the water from other sources finding its way into the general distribution system.

Many cases of this kind are recorded which are known or believed to have caused considerable outbreaks of typhoid or dysentery, or both.

In the body of the report of this same Committee is a discussion as to the regulations variously adopted to prevent pollution of this character. The least precaution suggested is that wherever dual sources of supply are used, one of which is from the general city supply the connection with the city supply should be made with two successive especially well designed check gates to prevent the possibility of any back flow, said check gates to be placed in a position where they are easily accessible for inspection and repair and to be so arranged that they can be cut off from pressure in either or both directions by positive valves on either side of them, so that each can be independently tested for tightness against back flow by means of proper pressure gage and tap connections, and that such tests for tightness should be made at frequent intervals. There are many, however, who advocate that no such dual connections should exist, but that if the city supply is to be utilized at all, in connection with other sources of supply, it should be drawn into supply tanks through pipe connections discharging freely into the top of tanks with no physical connection whatever between the city supply and other sources of supply.

There is considerable sentiment even that no possibly polluted supply should be piped into or used for any purpose about any plant, because there is always the danger that cross connections may be made somewhere inside of the plant inadvertently or that employes or others about the plant may use water from the wrong source.

It is quite possible that the difference between local conditions in different localities would fully warrant the above noted divergence of views, for instance, if the source or sources of secondary supply were just as attractive in appearance or taste as the city supply, but known to be dangerously polluted, the most extreme precautions would probably be warranted, whereas, if the source or sources of secondary supply were a highly colored or very muddy water so that it would be at once noticeable as compared with the city supply, even in a very small admixture therewith, and especially if said secondary sources of supply were not polluted and, therefore, not dangerous to public health, it would appear that it would be a great hardship and most uneconomical to prohibit their use for such uses as they may be even better adapted for than the city supply, or to condemn those who use them to the repumping of the city water whenever they desire to use the two waters together or interchangeably under a pressure not greater than the city pressure as is often the case in a fire protection system or in plants in which arrangements for dual sources of supply for other uses are found desirable.

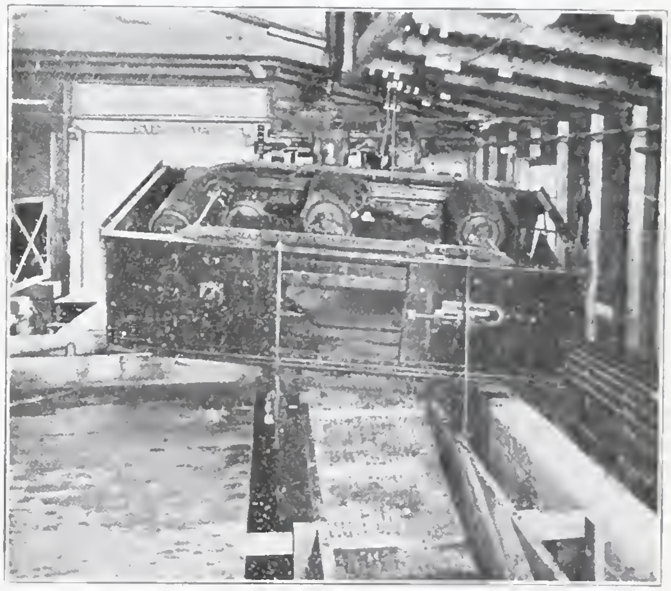
Results of 1918 Operations of Testing Station of Milwaukee Sewerage Commissions

Experiments conducted in 1918 at the Sewerage Testing Station of the Sewerage Commission of Milwaukee, Wis., demonstrated that:

A revolving screen with slots 2 in. x ⅛ in., working under a 2-in. loss of head, handles 3,000,000 gal. of Milwaukee sewage upon 27 sq. ft. of wet screen area per day, and removed 150 lb. of dry solids per 1,000,000 gal.

Activated sludge tanks, 15 ft. deep, treated the affluent from such a screen at the rate of 16.5 million gallons per acre per day.

The above are the conclusions of the report of Wm. R. Copeland, Chief Chemist of the station, as given in the 5th annual report of the Milwaukee Sewerage Commission for the year ending Jan. 31, 1919. Other information from Mr. Copeland's report follows:



Fine Screen for Testing Station of Milwaukee Sewerage Commission.

Fine Screen.—The fine screen is made with 38 bronze plates 32 in. by 18 in., each plate having 28 per cent of open space in the form of slots ⅛ in. wide. The screen resembles the Hamburg type in its general form, but the screenings are swept off by a system of revolving brushes. The slots are much narrower than the openings in the bar screens; therefore, it may be described as a fine screen. The screen was made in Milwaukee by the Chain Belt Co. and installed for two purposes:

1. To protect the aeration tanks from the coarse debris which has proved to be a serious detriment in the previous experiments upon aeration.

2. To get data upon the relative volumes of liquor passed, quantities of suspended matter removed, and losses of head developed by slots of several sizes.

The coarse bar screen and the grit chamber, through which the sewage flows before reaching the fine screen, removes much coarse material, such as rags, etc. Nevertheless, quantities of leather scraps, garbage, waste and hair reaches the screen, and some of this heavy matter passes through. The sewage varies in strength from hour to hour, but no attempt is made to vary the flow to correspond with the increase or decrease in the volume of liquor which appears in the interceptor at different hours of the day. Some variations of flow through the screen develop, however, as the loss of head changes.

The data given in a following table show that the quantities of sewage handled varied from about 2,600,000 gal. with a 2-in. loss of head to more than 12,700,000 gal. with a 6.7 in. loss of head.

Data obtained while operating the screen with various losses of head are given in Table I.

The data given in this table show that, whereas the volume of liquor treated per square foot of wet area increased with increasing losses of head, the pounds of screenings removed per million gallons of sewage treated decreased. Analyses of these screenings are given in Table II.

Operation of Aeration Tanks.—After passing through the fine screen, the effluent is forced by centrifugal pumps through the venturi meters into the aeration tanks.

The tanks may be described, briefly, as follows: All tanks had a net weight of liquid area of 284 sq. ft. and contained filtros (aerating) plates, type "S," guaranteed by the manufacturer to pass, when dry, 10 cu. ft. of air per minute under a pressure equal to 2 in. of water. One tank 15 ft. deep, contained 64 of these plates; a second tank, 15 ft. deep, contained 48 plates; one tank, 10 ft. deep, contained 64 plates, and a second tank, 10 ft. deep, contained 48 plates.

Standard of Purification.—Owing to the fact that the effluent from the sewage disposal works will enter Lake Michigan—the source of the city water supply—the sewage must be purified to a high degree, much more, in fact, than is customary in most American cities. Experiments conducted at this station during 1916 and 1917 established the fact that activated sludge will remove 90 per cent of the bacteria and 95 per cent of suspended matter. In view of the Milwaukee situation, the following standard was, therefore, adopted:

Removal of bacteria	90 per cent
Removal of suspended matter	95 per cent
Stability of effluent	3 days

Rate of Sewage Purification.—Experiments, carried out with Imhoff tanks and sprinkling filters in 1915, showed that it was possible to purify Milwaukee sewage at a rate 2,500,000 to 3,000,000 gal. per acre per day. This rate was raised in 1917 to 7,000,000 gal. by adopting the activated sludge process. The testing station was reconstructed in 1918 for the purpose of proving that its city sewage could be treated on Jones Island, economically and efficiently, at a rate of 15,000,000 gal. or more per acre.

The present plant was put into operation on Nov. 4 and the results obtained are indicated by the data in Table III.

From the data given in this table, it is evident that both the 15 and 10-ft. aeration tanks met the requirements of the standard with a margin to spare. Moreover, the volume of sludge produced per 1,000,000 gal. of sewage treated was smaller in the 15-ft. tanks than in the 10-ft. tanks.

Development of Activated Sludge.—In order to obtain the activated sludge required for treatment, all of the tanks were filled with screened sewage on Oct. 15. Every day or two thereafter, from 1,000 to 5,000 gal. of freshly screened sewage were run into each tank, replacing an equal volume of tank liquor drawn off. Air was applied continuously day and night, at rates ranging between 130 and 135 cu. ft. per minute per tank.

Within 96 hours after the first filling, the tanks assumed the golden brown color which is characteristic of activated sludge in Milwaukee. Within 15 days, more activated sludge had accumulated in each tank than was required for purification purposes.

Cleansing of Air.—Experience has shown in former experiments that the air on Jones Island is very dirty. It contains great quantities of coal soot. Such material, when introduced beneath the filtros plates, chokes up the pores and cuts off the air.

To prevent this, all of the air used in November and December, 1918, was cleansed, first by filtering through a layer of 12 ounce duck, then through a layer of canton flannel, and was finally washed in a Nash hydro-turbo blower. These treatments removed most of the soot.

Dorr Thickeners.—The mixed liquors, discharged by the aeration tanks, flowed to settling tanks equipped with devices known as Dorr thickeners. The principal features of importance in these tanks lie—

First, in power-driven mechanical scrapers which travel over the surfaces of the slightly cone-shaped tank bottoms and force the heavy, settled sludge out through a central drain.

Second, in the air lifts which raise the heavy discharged sludge to measuring devices described elsewhere as "tipping trays."

Third, in the efficient weir troughs by which the purified sewage is drained off from the surfaces of the tanks and discharged into measuring boxes.

The Dorr thickeners were installed for two purposes—to serve as settling basins for separating purified sewage from sludge, and to condense the sludge.

The effluents contained less than 5 parts per million of suspended matter, on an average, and the sludge, at times, contained less than 98.5 per cent of moisture. Therefore, the Dorr thickeners gave good service.

The aeration tank effluents entering the thickeners were applied at an approximate rate of 1,000 gal. per square foot of surface area per day. At this rate, the tanks contained a layer of heavy sludge at the bottom from 2 ft. to 3 ft. thick, and the top of the sludge blanket was about 8 ft. above the bottom. The scrapers made one revolution in four minutes and moved the sludge from the outer edge to the center in 10 minutes.

Analyses of the sludge discharged show that it varied in moisture from 97 to 99.5 per cent. The amount of moisture contained is affected to a large degree by the quantity and character of the sludge in the mixed liquors which enter the tanks and by the manner in which the sludge is drawn off.

When the areation tanks contain much sludge, as, for instance, 25 to 30 per cent (on one-half hour settling), the moisture in the sludge escaping from the Dorr thickeners will range between 97 and 98 per cent; when the aeration tanks contain 15 per cent or less of sludge, the Dorr thickeners will discharge sludges with 99 to 99.5 per cent of water. If the sludge is drawn off rapidly, top water breaks through and raises the moisture by dilution. If the sludge is drawn off slowly and continuously, a layer of thick sludge 2 ft. to 3 ft. deep remains on the bottom all of the time and prevents top water from breaking through.

When sludge is drawn off continuously at a rate of 13 per cent of the sewage flow, the sludge will carry 98 per cent (or less) of moisture. When the sludge is drawn off continuously at a rate of from 18 to 20 per cent of the sewage

TABLE I—DATA OBTAINED IN APRIL AND MAY, 1918, WITH VARIOUS LOSSES OF HEAD ON THE FINE SCREEN WITH ⅛-IN. SLOTS.

Loss of head	2 in.	4 in.	5.7 in.	6.7 in.
No. sq. ft. of wetted screen area	22.7	26.2	27.5	28.1
No. gal. sewage treated	26,156,000	42,217,000	55,640,000	89,540,000
Total average per day	3,737,000	7,036,000	7,950,000	12,793,000
Average per sq. ft. wetted screen area	115,200	161,100	202,300	318,700
No. of pounds of screenings collected	24,485	27,030	36,271	38,837
Total average per day	3,498	4,500	5,181	5,548
Average per sq. ft. wetted screen area	1,079	1,032	1,320	1,382
Average per million gallons.	953	655	650	441
Per cent moisture in drained screenings	88.1	89.0	88.5	88.5
Per cent rough suspended matter removed	6	9	6	5
Total suspended matter in sewage—parts per million.	239	219	249	250
Coarse suspended matter in sewage P. P. M.	193	157	143	127
Coarse suspended matter in screened liquor P. P. M.	181	149	134	119

TABLE II—PER CENT OF NITROGEN IN SCREENINGS.

Date.		Dry basis total nitrogen figured as		Basis 10% moisture nitrogen figured as ammonia	
	Regular	Nitrogen.	Ammonia.	Total.	Available.
Dec.	2	6.80	8.26	7.43	
	4	7.43	9.02	8.12	
	5	7.28	8.81	7.95	
	7	5.50	6.68	6.01	
	8	6.16	7.48	6.73	
	9	6.13	7.44	6.69	
	10	6.58	7.99	7.20	
	12	5.32	6.46	5.81	
	13	4.71	5.73	5.18	
	14	4.69	5.69	5.12	
	17	5.46	6.63	5.96	1.82%
	19	6.07	7.37	6.63	1.70%
	20	6.02	7.31	6.58	
	21	6.50	7.89	7.10	
	22	4.61	5.59	5.03	1.64%
	24	5.71	6.97	6.27	2.26%
Total		95.03	115.38	103.81	7.42%
Average		5.94	7.21	6.49	1.86%

TABLE III—STANDARD AND SUMMARY OF DATA

		North 15 ft. tank.	South 15 ft. tank.	North 10 ft. tank	South 10 ft. tank.
1918 Period.	Standard.	Nov. 4 to Dec. 29.	Nov. 4 to Dec. 29.	Nov. 4 to Dec. 29.	Nov. 4 to Dec. 29.
Depth in feet	15	15	15	10	10
Millions of gallons of sewage treated per acre per day	15	16	16	10	10
Per cent suspended matter removed	95	99 plus	99 plus	99 plus	99 plus
Per cent bacteria removed	90	95 plus	95 plus	95 plus	95 plus
Stability of effluent in hours	72	120 plus	105 plus	100 plus	95 plus

TABLE IV—EFFECT PRODUCED IN DEPTH OF SLUDGE IN THICKENERS BY CONTINUOUS VERSUS INTERMITTENT DRAW OFF.

Depth above bottom in feet...	1	2	3	4	5	6	7	8	9	10
Method of draw off.	Per Cent of Sludge by Volume.									
Tank No. 7.										
Continuous	94	93	86	19	13	5	4	4	2	1
Intermittent:										
Before	84	65	43	9	5	3	2	1	0	0
After	24	10	5	4	3	2	1	0	0	0
Tank No. 15.										
Continuous	77	50	22	4	3	3	2	1	0	0
Intermittent:										
Before	70	35	15	9	6	5	3	1	0	0
After	12	4	3	3	2	2	1	0	0	0

Note—Tank No. 7 received the mixed liquors from the North 15-foot aeration tank. Tank No. 15 received the mixed liquors from the north 10-foot aeration tank.

Quantities of sludge are expressed in per cent by volume after one-half hour sedimentation.

flow, the sludge will carry 98.5 per cent of moisture. When the sludge is drawn off continuously at a rate of from 30 to 35 per cent of the sewage flow, the sludge will carry 99 per cent (or more) of moisture, but when the sludge is drawn off at a rate of 50 per cent of the sewage flow, the sludge will carry 99.5 per cent or more of water.

The sewage, flowing into the aeration tanks, deposits fresh sludge continually. A portion of this material has to be wasted in order to keep the aeration tanks operating in a proper manner. The waste sludge may be drawn off intermittently or continuously, but the effect produced upon the volume of sludge in the Dorr thickeners and upon the character of the waste sludge will be radically different.

Aeration by Perforated Pipes.—Owing to the fact that filtros plates are rather expensive, a tank was equipped with grids of perforated black iron pipes as air dusters. Sludge and rust filled the pipes and holes up quickly, making it necessary to draw the liquor out of the tank and clean the grids within two days after starting up the run.

As such procedure would be entirely impractical in a large municipal plant, the grid diffusers were abandoned.

Filtros plates, set in cast iron containers and fed by black iron air lines, had to be torn out after a few months of service because iron rust gathered on the under side of the plates and shut off the air.

Air lines, feeding the filtros plates, should be made of some non-corrosive metal—such as galvanized iron—in order to prevent scales of iron rust from choking the lines feeding the filtros plates.

Swimming Pool Management

Swimming pool management is a subject that has received recognition in very few states, California and Florida being the principal ones to pass official regulations. Mr. William P. Mason, Professor of Chemistry, Rensselaer Polytechnic Institute, recently presented a paper on the subject before the 38th Annual Convention of the New England Waterworks Association, from which the following notes are taken.

Many swimming pools are poorly designed or constructed. The pool outlets are sometimes placed on the side which is incorrect. They should be on the bottom so that all settled matter may be drained. Frequently this may be accomplished by a few turns of the outlet valve and the sediment is flushed out. Gutters should receive proper care in the design. They should be accurately located.

Experience has demonstrated that the temperature of the water should be about 76° F. for the average swimmer but may be reduced to about 72° F. for match swimming. Turbidity is unsightly and frequently dangerous especially if the bottom is not visible. Many methods of treatment are available. Sometimes the water is renewed every week, but where water is expensive other methods are used. Alum treatment, ozone or ultra-violet are used. When filters are used the water is circulated through the filter and used for as long as a year. The continued use of alum reduces the alkalinity so that it is necessary to renew it at intervals with soda ash.

Outdoor pools are used to advantage in some places but are frequently troubled with algae growths when exposed to the sunlight. Copper sulphate will generally remedy this defect. Public baths should not be in polluted waters and care should be exercised in selecting their location.

Few states have adopted any bacterial standard for the water in swimming pools. Chlorination generally is used to control and reduce the bacterial content. The standard for bacterial content adopted by California is below 1000 per C.C.

Disposal of Nightsoil, Sewage and Garbage in Rural Districts

Rural sanitation as applied to the collection and disposal of nightsoil, sewage and garbage is the subject of the Report of the Committee on Sewerage and Sewage Disposal made before the recent New Orleans Convention of the American Public Health Association. The more important points of this report are here noted. The methods of disposal are typical and comparatively inexpensive.

Dry Disposal.—The principal methods of dry disposal are, the straddle trench, the pit privy, the receptacle privy and the chemical closet. They are limited in the number of persons accomodated and in extreme care necessary. Rural districts are frequently forced to rely on these methods alone.

No privy should be located within 20 ft. of a house; within 50 ft. of sleeping or eating quarters in a camp or cantonment; within 50 ft. of a stream; or, if leaching into the soil is possible, within 200 ft. of any body of water that may be used for household purposes, or upon land draining directly toward a well, spring or stream thus used.

Wet Disposal.—The cesspool is, in effect, a deep pit privy with a pervious lining.

Cesspools are usually from 7 to 12 or more feet in depth and the minimum capacity may be placed at about 80 cu. ft. They permit gross pollution of the subsoil and so should be only used in remote regions and where the water supply is brought from a higher level and from a considerable distance, depending on the formation. They should not be used where the ground water stands within 10 ft. of the surface, or where, as in limtstone regions, natural underground channels may exist.

The cesspool should be cleaned when filled to within not less than 2 ft. of the top.

The Septic tank is generally to be recommended for isolated houses having a public water supply and a soil favorable for subsoil irrigation for the effluent.

For single houses the capacity, including space for sludge, should equal the volume of sewage to be received in about 36 hours, or say 10 cu. ft. for each person.

The tank should be cleaned annually. To promote bacterial activity a few pints of sludge from a neighboring tank or a little stable manure should be placed in the tank when first used.

The Imhoff tank is to be preferred to the septic tank for larger installations, such as institutions, hotels, etc., as there is less liability to offense in the disposal of the sludge. The period of retention should be from 5 to 20 hours, depending on the number of persons served.

The effluent from either type of tank may pass to a body of water that is not used for drinking purposes if conditions for dilution are otherwise favorable, but in most cases it should be first oxidized in some other way.

If it is desired to effect a greater degree of purification than the mere removal of suspended solids, the tank effluent should be subjected to one of the following "oxidizing" processes.

Trickling filters and contact beds are adapted in particular to large installations where the services of an expert are required both in the design and operation.

Surface irrigation, unless under expert supervision, is not recommended, as offering too many opportunities for the production of odors and mosquitoes and for infection through flies.

Subsurface irrigation by lines of open joint tile laid from 8 to 15 in. below the surface may be the best method to employ provided the soil is not water-soaked or too impervious. The former difficulty is sometimes overcome by embedding the tile in a light fill of sandy soil. The irrigated area should be at least 150 ft. from any habitation.

To prevent clogging the soil the sewage should pass through a grease trap at the house and to promote aëration in the soil it should be delivered intermittently from 3 to 6 times a day (somewhat less if the soil is dense) by a siphon contained in a dosing chamber after leaving the tank. This device may usually be omitted, however, where the house is only occupied during the summer.

The tile should generally be 3 or 4 in. in diameter, laid with a piece of tar paper over the joint and with a gradient of from 2 to 6 in. per 100 ft. The length depends upon the volume of sewage and character of the soil, varying from 50 to 100 ft. for an ordinary family. Where more than 100 ft is required in all it is generally desirable to lay two or more lines of tile. The arrangement may vary with the topography but parallel lines should be more than 6, and preferably 10 ft. apart.

Unless the conditions are favorable and other satisfactory methods are not feasible, subsurface irrigation is not recommended.

Sand filtration may be used for tank effluents where more than 25 persons are served and where the land is suitable. For this number of persons an area of about 1,500 sq. ft. of bed is required. The filters require careful design and maintenance. Cropping is usually undesirable. Dosing should be intermittent and applied in rotation to a depth of from 3 to 6 in. to two or more beds. In winter the beds should be furrowed to prevent freezing.

Sludge from tanks should be dried on porous soil or on specially prepared beds. It should be placed in layers of from 4 to 10 in. in thickness—the thinner the better—until sufficiently dry to be spaded, when it can be buried, plowed under or used as fertilizer.

Disposal of Garbage.—Garbage should be collected without admixture of ashes or other material in metal cans having tight covers, with one always available while the others are being emptied. The cans should be scalded with hot water after emptying.

Garbage from households may be satisfactorily disposed of by burial.

If without too large a proportion of moist vegetable matter a moderate amount can be safely consumed in the kitchen range, although at the risk of odor; while if the quantity is sufficient, as in a construction camp or a military cantonment, a small but well-designed incinerator will eliminate much of this objection.

Probably the most economical method for the farmer and for towns of moderate size is in feeding to hogs, due care being taken to maintain cleanly conditions about the pens. The garbage should not be kept more than 48 hours in any case before feeding. On account of the possible nuisance from smells and flies the pens should be located, if possible, at least a quarter of a mile from dwellings.

Disposal of Manure.—Fifty horses will produce a cartload of manure a day. Fly breeding may be prevented by an application of borax, using not over one pound to 16 cu. ft. of manure if the latter is to be used as a fertilizer, but a better plan is to sprinkle with a solution of 2 lbs. of copperas per gallon of water, or with a solution of hellebore mixed in the proportion of 1 lb. to 20 gal. of water and applied at the rate of a gallon of the solution to each cubic foot of manure. By consolidating the exposed surface of the manure by battening with a spade it will prevent to a considerable extent the breeding of flies. The heat generated just below the surface by decomposition is then such that the larvae are largely destroyed.

The most natural use for manure is as a fertilizer, but where this is impracticable it may be piled in windrows about 2 ft. high, saturated with oil and burned.

Of the safeguards against disease in our rural communities those relating to the protection of water supplies and to the transfer of disease germs by flies are by far the most important; so that, whatever method of disposal is adapted to a given situation it should be such that no excretal matter can find its way, either by percolation through the soil or by surface wash during storms, to wells or streams used for drinking purposes, and that all such excretal matter shall be so protected by screening or otherwise that flies cannot find access thereto.

Engineering Students at University of Illinois.—The number of undergraduate students registered in the College of Engineering of the University of Illinois on Nov. 1, 1919, was as follows:

Architecture	127
Architectural Engineering	147
Ceramic Engineering	47
Civil Engineering	326
Electrical Engineering	445
General Engineering Physics	2
Mechanical Engineering	515
Mining Engineering	58
Municipal and Sanitary Engineering	11
Railway Engineering	36
Total	1,714

Recent Practice in Garbage Disposal by Feeding to Pigs

The method of disposing of garbage by feeding to swine seems to be growing in popular favor. Several reasons account for this: First, war economy agitation; second, low initial investment; third, adaptability to small cities and villages; fourth, conservation of waste materials; fifth, high cost of construction of reduction plants and high cost of construction and operation of incinerators. Recent data on this method of disposal are given in the report of the Committee of Refuse Disposal submitted at the recent convention of the American Public Health Association. The matter in this article is taken from the report.

It is impossible to state how many of the smaller municipalities have taken up feeding during the year but there are some notable instances in large cities and, in these, several points that stand out prominently as indicating that substantial progress is being made in treating such problems in a scientific manner. It would seem, however, that the careful thought necessary to put the method on a sound sanitary and economic basis has only begun to be applied and that much more study of the economic factors and experience with structural features at the piggeries is required before feeding can be regarded as a competitor in all respects with the older and more thoroughly tried methods. Elimination of nuisances is doubtless the greatest difficulty with which pig feeding is beset, and until some means of handling both the feed and the swine so as to restrict conditions objectionable to sight and smell to the smallest possible area are standardized this method of disposal can not be expected to merit the popularity to which it is entitled.

In Table I the arrangements at Newark, N. J., Baltimore, Md., and Buffalo, N. Y., are compared in as much detail as it has been possible to obtain. It will be noted that the cost of reduction plants has been an important factor in influencing the decisions to resort to feeding. In each instance an attempt has been made to eliminate chance by basing the price paid for garbage on the market value of killing hogs, Chicago being taken as the standard. There seems to be indicated an effort to eliminate nuisance and to provide for keeping the hogs in good physical condition by giving some attention to housing and feeding conveniences.

Primary separation has been forced upon the cities by the nature of the disposal adopted and efforts will be made to obtain hotel and restaurant garbage by restriction against unauthorized collectors.

It is assumed that the stock will be protected against disease by inoculation. Baltimore will employ a veterinarian for continuous supervision and inspection of the work of the piggery. It is said that garbage should not be fed to growing pigs under four months old or 100 lbs. weight, and that brood sows thrive on garbage but should be removed and given better feed shortly before the birth of the pigs.

At Pontiac, Mich., the loss from inoculation and cholera has been negligible, but from pneumonia 3 per cent to 4 per cent. Pens of stock dead from this cause should be disinfected with lime and coal tar products and the ground plowed. New pigs should be cleaned and disinfected for lice. Eight to ten acres are in use for 100 to 150 hogs. Part of the area should be cropped each year and the rest thoroughly cleaned and plowed at intervals of two or three months. The material cleaned up may be composted for fertilizer. The population of Pontiac is about 40,000. It is estimated that about 400 hogs could be supported.

St. Louis, Mo., has made a temporary one year arrangement whereby garbage from the outskirts will be sold to various hog farmers for 25 ct. per ton. They will take from one-third to one-half the total amount produced by the city. The rest is to be sold delivered to a feeding farm to be located within 50 miles of the city. The estimated cost to the city after delivery is 5 to 10 ct. per ton. Under the old re-

TABLE I—COMPARISON OF GARBAGE CONTRACTS OF NEWARK, BALTIMORE AND BUFFALO.

Location.	Estimated population.	Area sq. mi.	Contract effective.	Duration of contract.	Price per ton paid by contractor.	Collection and delivery.	Separation.	Material included.	Estimated daily collection.	Estimated number of hogs.	Housing of hogs.	Feeding facilities.	Reduction considered?	Previous arrangement.
Newark, N. J.	450,000	23	July 3, 1919.	5 years.	8 times top price per lb. Chicago killing hogs.	City collects and delivers to piggery.	To be enforced.	To be attempted.	100 tons.	5,000 in summer.	Unit buildings 100 ft. sq. 80 to 100 hogs each. Saw-tooth roof. Windows, top and sides.	Double concrete driveway and feeding floor, 24 ft. wide through center each building. Gutters on each outer edge next to pens. Pens slope to gutters. Yard 50 ft. deep for each pen.	Yes, but cost too much. $750,000 exclusive of land.	Combined refuse dumped $3,000 realized annually from salvage.
Baltimore, Md.	720,000	80.5	May 1, 1919.	1½ years.	3½ times top price per lb. Chicago killing hogs. Garbage drained before weighing.	City collects and delivers 16 miles by barges to piggery.	To be enforced.	Household garbage and animal market refuse.	140 tons.	15,000.	Shaded yards, 70 ft. by 250 ft., 100 hogs each.	Concrete feeding floors. Garbage unloaded and spread by machinery. Must clean platform each day.	Yes. Bids asked but none received.	Reduction cost $1.06 per ton. Temporary burial cost 85 cts. per ton.
Buffalo, N. Y.			Oct. 1, 1919.	5 years	Minimum 50 cts. per ton. 6, 7 or 8 times above according to amount of garbage.	City collects and delivers to feeding platforms.	to be enforced.		100 tons.					Reduction.

duction contract the city paid 87 ct. per ton delivered to loading docks.

It is reported that in Spokane, Wash., hog feeders have agreed to purchase at the cost of collection all edible garbage delivered to them at the crematory plant. This method of utilization was decided upon because of the increase in garbage since the close of the war and indicates that the war lessons on conservation have not been lost on the city officials though they would seem to have been lost sight of by the householders.

Minneapolis has abandoned incineration in favor of pig feeding. The contractor pays $1.26 per ton and hauls it about 6 miles to the piggery.

The fact that the installation of a pig feeding plant is comparatively cheap has undoubtedly influenced many city officials to regard wasteful methods and insanitary surroundings as unimportant. Chief among wasteful methods may be cited the amount of food often allowed to go to waste on account either of its stale condition on reaching the feeding place or the keeping of an insufficient number of hogs to consume it. It is by no means uncommon to find half of the garbage rejected by the swine, and this raises the very important question of disposal of the residue. Burial or plowing into the soil is expensive and requires large areas which are not always available. Dumping gives rise to nuisances and it is doubtful if either incineration or reduction is possible. The most logical solution would seem to be in maintaining a collection system of sufficient frequency to obtain fresh garbage and keeping a herd large enough to reduce the rejected material to a minimum and depend on burial to dispose of the unavoidable accumulations.

The Prevention and Cure of Red Water Plague

People who live in districts supplied with soft water are familiar with what has been termed the "red water plague." This condition of the water is caused by the presence in it of hydrous red oxide of iron commonly spoken of as rust.

In a paper read before the New England Water Works Association at its meeting Nov. 12, Mr. Wm. H. Walker, Professor of Chemistry, Massachusetts Institute of Technology, tells of some comparatively recent experiments and the results on the treatment of such waters. The following notes are abstracted from this paper.

It was for many years thought that rust was formed by the direct union of the oxygen of the air, water and the iron, but such is not the case. In order to form rust the iron must actually go into solution in the water: if oxygen is present, it later unites with this dissolved iron separating as red rust. Where iron dissolves in water, hydrogen is set free from the water and forms a protective coating over the surface of the iron. But if oxygen is present, it unites with this hydrogen, destroys the protection and allows the solution of the iron to proceed. The hydrogen polarizes the surface of the iron, and the dissolved oxygen acts as a depolarizer. Experiments have established the fact that, other factors being the same, the amount of corrosion is directly proportional to the free oxygen content of the water.

The removal of the free oxygen content is now accomplished upon a commercial scale for hot water softeners by an apparatus called a "deactivator." The water from the main passes through a heater to raise the temperature to 160° F. and then through a storage tank containing a large number of iron sheets chemically treated so that rapid corrosion of their surface takes place. The oxygen is promptly consumed by corroding these cheap and easily replaceable sheets. The water finally passes through an ordinary filter.

In one plant installed for experimental purposes in an apartment house in Boston, the sheets were removed after two years' service and showed a loss of 25 per cent in weight. No trouble with the piping had developed during that time.

The advantages of this system are that the removal of oxygen is automatic and does not change the quality of the water for domestic purposes. No attention is required other than the removal of the accumulated hydroxide from the filter by washing.

The Experience of the Army in Utilizing Camp Wastes

Many municipalities can study with interest and profit the experience of the army with the utilization of camp wastes. While the details of the army methods may hardly be practicable with the conditions usually found in civil life, the fundamental facts that utilization need not be injurious to health, that it need not cause nuisance, that it is less expensive of operation than other methods, that it is of economical importance to the community and to the nation, hold for civilian "camps" as well as those of the army.

Valuable information on the army methods, furnished by Mr. F. C. Bauman, is given in the report of the Committee on Refuse Collection and Disposal, presented at the recent convention of the American Public Health Association. The matter following is taken from the report.

Before the war, camp wastes were disposed of either by burning, burial or removal. The army's interest in camp waste utilization only began with the National Army cantonments. The almost universal method before that time was incineration. Possibly the fact that army waste disposal matters were so largely a province of the army medical departments, whereas the tendency in municipal corporations is toward treating disposal as an engineering problem rather than one for the medical profession, may have had an important bearing on the rigid adherence to the destruction method.

There are no data to indicate that the policy of waste utilization, rather than its destruction, has injured the health of the men in camp, or that of the workmen regularly handling such wastes. Experience has unquestionably demonstrated that the household wastes of congested communities, their garbage, paper, rags, and like materials, can be salvaged without endangering the public health of such communities to the slightest degree, and that the net cost of thus disposing of such wastes is far less than that of any destruction method.

The amount of pork and other valuable materials available through the utilization of army garbage cannot be definitely determined. Experiments have shown that an average daily ration of 20 lb. of camp garbage will produce a gain of 1 lb. per day in the hog. The average wastage for 1918 can certainly be assumed as 1 lb. per man per day. For the year, this assumption would give 18 lb. of pork as the production for the garbage of one man.

The daily average number of men in camp during 1918 was approximately 1,500,000. This figure at 18 lb. per man would give the pork as produced as 27,000,000 lb. for the year.

It is very doubtful if the actual production even reached half of this amount. The above estimate makes no allowance for pigs dying, uneaten garbage and numerous other factors, all tending to diminish the output. It is more than safe to assume, however, that 40 per cent efficiency was attained or that nearly 11,000,000 lb. of pork raised on camp garbage was sold during 1918. With the need of fats and pork products, this was in no sense a small contribution.

The first government contracts for utilization expired on June 30, 1918. The specifications of the above contracts provided for segregation into fats and tallows, bones and other garbage; paper, rags or twine, bottles and jars, and tin cans. One contract generally included all of the waste from a given camp and elaborate sanitary requirements were included, the contractor, for example, not being permitted to dispose of the garbage within 6 miles of the camp.

Since July 1, 1918, bread is being kept from other kitchen wastes, not because it is a fine chicken food and worth more as such than as hog food, but because it was necessary to conserve wheat and, by requiring that all bread wastage be kept separate, one camp could be weighed against another and special attention paid those showing high per capita figures for this class of garbage. For a like reason cooked meats, greases and other separations were agreed upon.

The following articles are injurious to hogs: coffee grounds, broken glass or china, soap, lye, washing powders, dishwater, papers, cans, rags, floor sweepings, ashes and other dirt.

Prior to July 1, 1918, the average mess waste for all camps in the United States was nearly 2 lb. per man per day. This is far in excess of the wastes reported for municipalities and even exceeds the wastage per person of first class hotels, where it is impossible to use up "left-overs" as in the average household.

The effect of the new contracts on garbage production was prompt and positive. In October, for example, the average for the United States was 0.7 lb. per man per day, a drop of over 1 lb. in four months. Following October, the per capita increased slightly, but this upward movement has been checked and the present rate of wastage is again in the neighborhood of ¾ lb. per man per day.

The increased waste per capita during November and December was undoubtedly due to carelessness in the camps. Municipal records indicate that they, too, had a greater wastage during these months than previously. Probably with the signing of the armistice, people in general felt that their moral obligations to save food ended. In the case of the municipalities there has been no organized effort to check this increase and present figures will show a considerable advance over those of last year. In the army this tendency towards increased wastage was immediately checked by the action of the Quartermaster Department officers.

The gradual reduction in per capita waste for the four months, July, August, September and October, clearly indicates that the new contract has achieved its main object, namely, a reduction in camp waste. The temptation to build up an estimate of what such a reduction means is too strong to be resisted; the results are surprising. Assuming that the reduction for the four months' period is 1 lb., or that the average saving per month has been ½ lb., the food saved during the four months' period mentioned is roughly 60 lb. per man. Since the average number of men in camp during that period was approximately 1,500,000, there has been saved from the garbage and made available for other uses some 45,000 tons of army foodstuffs. Assuming still further that the average cost of army food is 13 ct. per pound, gives the rather astounding total of $11,700,000 saved in four months through the operation of these contracts.

The Orifice as a Means of Measuring the Flow of Water Through Pipes

The measurement of the flow of water in pipes by means of an orifice is possible when certain conditions are followed and values approaching accuracy within about 2 per cent are permissible. Bulletin No. 109 of the University of Illinois Engineering Experiment Station contains data on recent experiments made under varying conditions and presents conclusions for a working basis. The following notes are from this bulletin:

The tests were made on 4, 6 and 12 in. pipe with velocities ranging from .01 ft. per sec. to 23 ft. per sec. The orifice was a 3/16 in. thick steel plate with a square edged hole of various diameters inserted in a flange connection in the pipe. Drop in the pressure head was measured by a U-tube differential gage. The required location of the gage connections was found to be 0.8D upstream and 0.4D downstream from the orifice where D is the diameter of the pipe. Having determined the difference in the pressure heads at the two sections the velocity and hence the discharge may be determined from the formula

$$V = 4.85 \frac{h_D}{\left(\frac{D}{d}\right)^2 - \left(\frac{d}{D}\right)^2}$$

where h_D = the drop in pressure head (ft. of water)
D = diameter of the pipe (inches)
d = diameter of the orifice (inches)

The coefficient will vary under different conditions but for approximate values of V, the value given above will serve providing the diameter of the orifice does not exceed ½ the diameter of the pipe, nor less than 1/6 or, in other words, the values of $\frac{D}{d}$ should lie between 2 and 6.

This method of measuring discharges is recommended for obtaining yields of individual wells, the consumption of mills and factories and in other places where a more expensive or elaborate apparatus is not warranted.

MANAGEMENT AND OFFICE SYSTEM

This section is published twice a month: (1) In the Waterworks and Hydraulic Monthly issue, and (2) in the Railway and Excavation Monthly issue. It covers what may be broadly termed "management engineering" as applied in the civil engineering and construction fields.

Graphic Scales Adjusted for Clearness of Interpretation

In a paper entitled "Graphic Metallurgical Control," presented at the Chicago meeting of the American Institute of Mining and Metallurgical Engineers in September, and published in the Transactions of the Institute, Mr. H. M. Merry, Metallurgical Statistician of the Chino Copper Co., at Hurley, N. Mex., describes methods of plotting which have been successfully used by the company in cases where several graphs requiring different scales were to be jointly interpreted.

To properly comprehend the operation and metallurgical results from a concentrating plant, a daily record of essential data is kept, usually involving the dry weight of ore milled or treated, dry weight of concentrate or metal produced, assay values of heading, assay values of tailing, assay values of concentrate, and percentage of extraction or recovery. In addition it is often necessary to record moisture, pulp density, or dilution, percentage of weight of oils and reagents employed; screen analyses of grinding conditions, oversize, etc.; assay values of non-valuable or interfering substances; cost data; and such special information as may be required.

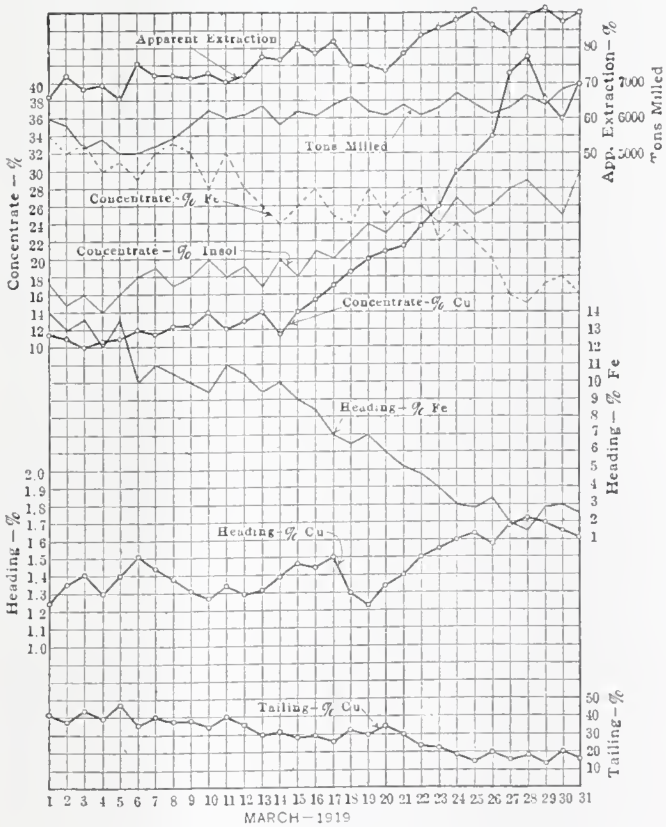


Fig. 1—Daily Metallurgical Record, Type I.

Graphical Presentation Methods.—Close analysis is necessary of daily operation involving such a number of factors, the relation and influence of which may be of great importance in the treatment scheme. When the analysis is made from a numerical tabulation, the chance for one or more obscure, but perhaps important, tendencies to escape notice is considerable, therefore the need for an accurate, readily digestible presentation of metallurgical data is obvious.

Graphic records of milling operations are frequently used, but owing to the wide range of magnitude and values, and the number of factors involved, the customary practice of assigning different values to the same ordinates, as in Fig. 1, results in a complex and intricate record which makes little appeal to a busy operating official. The methods shown in Figs. 2 and 3 are devised to display such data in a clear and legible manner, without confusion.

Semi-logarithmic Method.—This method depends on the use of cross-section paper with logarithmic horizontal ruling and arithmetic vertical ruling. Time is laid off on the vertical lines and values are assigned to the horizontal logarithmic scale. Three complete logarithmic scales are required to embrace the range of percentage and tonnage considered in the average milling operation. Four scales are preferable, but such ruling is not available unless hand-drawn.

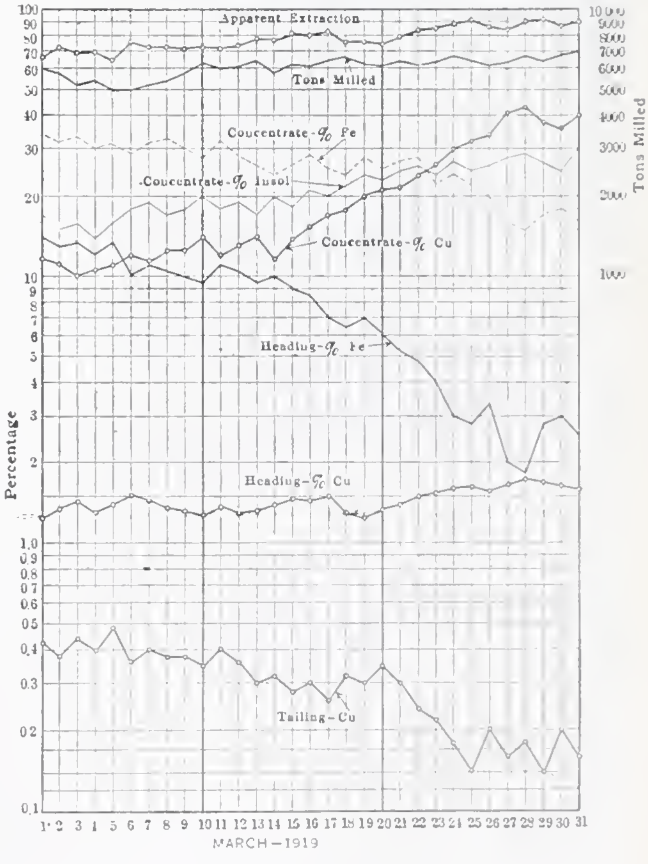


Fig. 2—Daily Metallurgical Record, Type II.

The graduation of the scales on the record, shown in Fig. 2, is self-explanatory and any one familiar with the slide rule can grasp the method. By this scheme all factors are shown in their proper relative position and tendencies may be closely observed and compared. The only disadvantage in this method lies in the fact that high points are depressed and low points exaggerated, which sometimes leads to erroneous conclusions. For this reason it is more applicable to the needs of the engineer than to general use. The great advantage obtained is the presentation of wide variations of magnitude in a small space, a range of from 0.1 to 100 in direct sequence being possible, and without confusion, the range may be increased to 10,000 in the space of a letter-size sheet.

Special Arithmetic Method.—Millimetric ruled cross-section paper, available in 50-yd. continuous rolls 22 in. wide, is used preferably for this method, which might be described as logarithmic notation on an arithmetic scale. This notation is original and is of marked advantage in plotting metallurgical data. Sheets 4 ft. in length, of full width, are commended. The notation of the scale should be so arranged as to display the various factors with due prominence. Assay values of heading and tailing which are the minimum and also the governing factors, should be exaggerated. Beyond the maximum range of heading assays of valuable metal, the scale may be reduced, the concentrate assay values, dilutions, extractions, etc., falling principally in this range. The tonnage scale is devised to meet the maximum and minimum variation and may include concentrate production. It is permissible to overlap the tonnage and percentage scales, preferably in multiples of ten, employing lines of different weight or color to distinguish them in conflicting areas. Abnormally high or low points that fall outside the limits of the particular scale should be plotted on the projection of the scale in which they originate, since breaking scale destroys the proportion of the relationship with other lines.

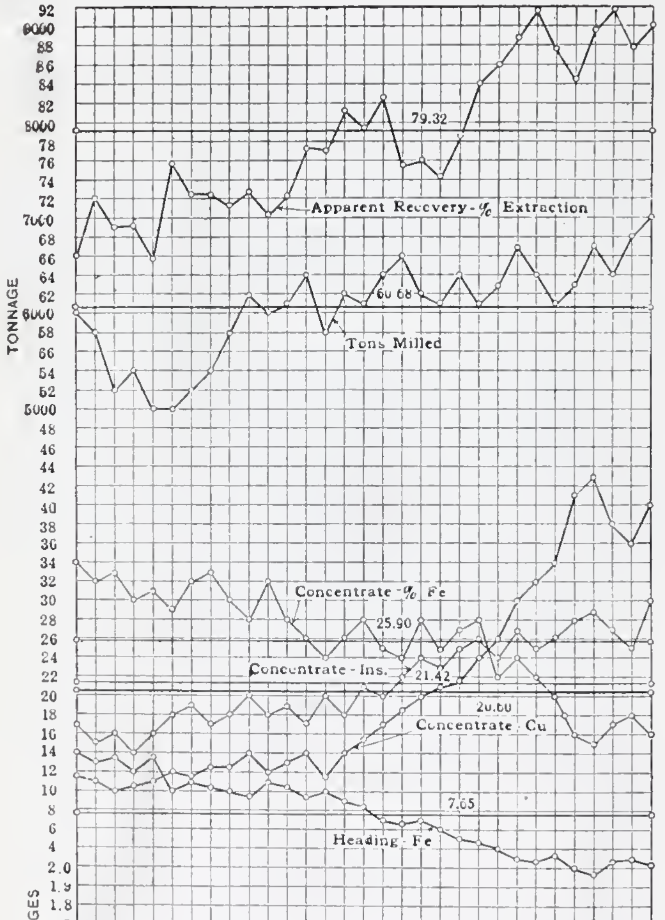


Fig. 3—Daily Metallurgical Record, Type III.

Under date of Mar. 28, Fig. 3, the position of all points except that representing per cent of iron in heading needs no explanation, as they are referred directly to the notation on the scale. The iron, however, falls below 2 per cent, at which the descending scale breaks from a rate of 2 per cent per centimeter of 0.1 per cent per centimeter. If the point is plotted to the scale notation it will be out of proportion to all other similar points, so the 2 per cent per centimeter scale is projected downward to 1.5 per cent and the point plotted. On the scale notation it appears at 1.95 per cent, but by referring to the origin of the scale in which all other live points are found, a wrong inference should not occur.

The average line drawn through each curve is the average "per day" for the month, and not the average for the month compounded daily to date, which would appear as a median line on the chart.

Worker—Not Wizard

"Burbank, the plant wizard," may well sound less pleasing than is intended to the great scientist of Santa Rosa. For 40 years he has worked with energy and intelligence for from 10 to 14 hours per day, and he can sacrcely welcome the suggestion that his success is due to something mysterious rather than to normal powers studiously and laboriously developed to a height of which any man should be proud. Any scientist, any professional man, any man or woman, in fact, who deeply desires success can not but find inspiration in the life of Luther Burbank. Not only inspiration and evidences of the reward of hard work are there to be found, but the practical carrying out of difficult scientific problems furnishes suggestions for procedure in other lines of endeavor.

One fact must be borne carefully in mind: Mr. Burbank's success is not measured by the wealth it has brought him, for wealth has not been his goal; but when he needed friends for the conduct of his work, he proceeded by sound business means to get them, thus giving further evidence of his ability and well rounded development.

In a past number of the "American Magazine," under the title "Burbank at Seventy," Mr. Walter V. Woehlke writes of this most interesting man. Mr. Woehlke says:

"Fifty years ago Luther Burbank did not stand out from the mass of other New England youngsters. On the contrary, he was rather below the average size and not at all robust. He worked in a plow factory for 50 cts a day, clerked in a furniture store, and started out to study medicine. Then a long siege of ill health, caused by a sunstroke, overtook him; and in 1875 he went to California to regain his strength, and to acquire a seed farm. He had just sold his first discovery, the Burbank potato—500,000,000 bu. of this famous tuber have been grown so far—and the $125 he received for this plant barely enabled him to pay for his ticket.

"Around Santa Rosa he earned an occasional dollar by cleaning chicken coops. And when at last he found a steady job in a nursery the pay was so small that he could not afford to rent a room. He slept in the steaming, dripping hothouse until fever overtook him. Only the kindness of a poor woman who brought him a pint of milk a day for weeks enabled the youth to survive. After his recovery he found steady employment and saved the larger part of his wages that he might reach his goal, a nursery of his own.

"'Man has a great advantage over plants,' said Mr. Burbank, in speaking of his early struggles; 'the young plant is at the mercy of its surroundings. Of itself, it cannot move from poor soil, or escape unfavorable conditions. But the human plant has the entire world to choose from. I had found the environment ideally adapted to my work, but the start was not easy. The first year the total sales from my nursery aggregated only $37! The second year they rose to $200. In order to live, I worked 10 hours a day for wages, and looked after my own business in the evenings.'"

Burbank the Engineer—There follows an account of a display of ingenuity of a truly engineering type; but let us not forget that deep knowledge acquired through a long and tedious period of work and study, coupled with an energetic application to the task immediately in hand were the things which brought success.

His real chance did not come until the third year, and even then it was a chance to do what everyone said could not be done. An impatient fruit grower was making the rounds of the California nurseries looking for 20,000 young prune trees to be delivered ready for planting within 10 months. Not a nursery would undertake it. Such a thing was considered impossible. But when the struggling nursery owner of Santa Rosa heard of the order, he went after the contract for the 20,000 trees, and immediately started to produce them.

Because no other seeds would sprout so late in the season, he planted almonds in beds of moist sand, covering them with cloth to maintain the proper moisture and temperature. As the almonds sprouted, they were removed one by one to the nursery rows. Then he scoured the surrounding orchards for prune buds, and as soon as the young almond trees were far enough advanced, the prune buds were budded into them and the tops of the young trees were broken off, thus forcing them to make a new growth. Within a little more than six months, young Burbank had delivered 19,025 prune trees ready for planting. He had done the impossible.

"Most of us, young, middle-aged, and old, are surrounding ourselves with self-created limitations," said Mr. Burbank, in referring to this incident. "Because a thing has not been done before, because nobody around us is doing it, we assume that it is impossible. In every plant and in every human being there are forces and powers of a range so wide, of a potentiality so great, that few people realize their full extent."

The high development of Mr. Burbank's senses, particularly his sense of color, is mentioned by the writer, who continues: "Through conscious and deliberate training, Mr. Burbank's eyes have become able to detect the minutest detail with startling clearness. He can see at a glance whether a building is even a quarter of an inch out of true, or whether a wall deviates an inch per hundred feet from a straight line.

"'There is no magic in it,' explained Br. Burbank. 'Every person equipped with a good nose and a good pair of eyes can reach the same sensitiveness by practice, patience, and concentration. Of these, concentration is the most important. The man who wants to accomplish anything worth while must learn to close his mind to all non-essentials and to focus it upon the task in hand with a burning intensity. Long hours of labor are valueless if the mind wanders. The average man rarely sets the undivided force of his mind to work on a single task continuously. He thinks of the automobile he is going to buy, the show he is going to see, or the raise he thinks he ought to have.'"

Burbank the Business Man.—After commenting upon Burbank's indifference to wealth, Mr. Woehlke continues:

"After he had accomplished the impossible and delivered 20,000 young prune trees in less than 9 months from the planting of the seeds, his nursery flourished. Year by year his establishment, his trade and his income grew. The Burbank nursery became an exceedingly profitable commercial institution. I am stressing this fact because Mr. Burbank's commercial acumen has been doubted by many of his later-day California friends. They fail to remember that he could not have carried on this very expensive plant-breeding work with practically no financial assistance from any source unless he had ample means of his own, and that he accumulated these ample means by his own unaided efforts, by operating a commercial nursery before he devoted all his time to the breeding work.

"'It is not difficul to start in business and to make the business profitable," explained Mr. Burbank. "The mainsprings of business success, in my opinion, are concentration and persistence. Concentration must include the mobilization of every faculty and every resource to bring about the desired end. Concentration means the focusing of all one's energy upon the job that is to be done. When I started in the nursery business with no capital except my two hands and a body weakened by illness I worked 14 hours a day, and gained strength by it. I saved the wages I earned and invested them in my business. I had my choice between spending $5 for buggy hire on Sunday, with the other young fellows, and business success. Since I had made up my mind to have the nursery, I had to forgo the buggy rides. It is all a question of what a person wants most. One can't have joy rides, expensive, time-and-energy-consuming pleasures, and keep moving toward the goal of success at the same time. In the course of 10 years, there are just so many hours; and the average normal man has just so much energy to spend. Where he will be, how he will stand in the community at the end of the 10 years, will depend almost wholly on the use he has made of the hours and his capital of energy.

"'I have little sympathy for triers, slackers and whiners. I prefer the doers. Providence and nature intended every normal human being to render the service for which he is fitted. It has been proved time and again that the normal man has in him the latent capacity for far greater things than he accomplishes in his daily routine. It is only a question of arousing this capacity and establishing the habit of putting it to its best uses constantly.

"'Sporadic excellence and improvement will not get a man very far. Like the plant breeder, he must learn how to fix the new traits and characteristics he develops so that the improvement will be a lasting one that can be transmitted to future generations.

"'We can't select the best individual human beings, keep them for breeding purposes, and kill off all the rest. Nor is this necessary. Man has in him the power of conscious self-improvement, and the exercise of this power makes every succeeding step easier for the individual.'

"When Luther Burbank first revolutionized the practice of plant breeding by experiments with hundreds of thousands of plants, where others used tens or dozens, his senses were not sharp enough, his memory was not retentive enough, his mental capacity was not great enough, to carry more than two or three experiments to a successful conclusion at the same time. But as the muscle that is exercised daily responds by increasing vigor and strength, so his mental and physical equipment grew as he made greater and greater demands upon it, until now he is able to conduct—and keep fully familiar with every detail of—more than 4,000 different experiments.

"'It's an old and trite saying, but profoundly true, that every beginning is hard,' continued the plant philosopher of Santa Rosa. 'If I had attempted to do 30 years ago what I am doing now, I should have failed. In the beginning we must be careful not to undertake that which is beyond our power. Failure at the start leads to disappointment and despair; and despair paralyzes the driving machinery of the average individual. But once the first step has been taken, once the foot is on the first rung of the ladder, there must be no turning back for some new and easier path.

"'Alongside of the will of the plant to live and bear fruit, man's will is as the feather is to the steel bar. Yet the human will can be developed through steady exercise. If we will only persist in doing the hard things we know we ought to do, we will be astonished at the increase in our will power, and delighted to find how much easier the hard task becomes through constant repetition.'"

Trade Periodicals Changed Failure to Success

The executive head of a California concern found his business slipping slightly but steadily behind in the race with his nearest competitor, apparently because the latter succeeded in beating him to small improvements. The difficulty, and what was done to overcome it, are described by Mr. V. W. Killick, in an article entitled, "A Progress Tickler," in "System" for September, 1919. After finding imitation of the competitor too slow a method to bring satisfactory results the executive decided to go after his own ideas. He had a list made out of over 100 periodicals, trade journals, newspapers and books, that carried information of interest to the concern. Of course no one man could carefully read all of these.

It was found that 63 of these publications were already being subscribed for by the employes of the firm, who read them for pleasure or profit. The firm then offered to pay for any one publication for any one employe, upon the condition that he read thoroughly each issue of the publication. The employe was then to mark articles he thought would be of interest to the management. Sometimes an entire article would be marked, sometimes only a few lines; the employe always kept in mind that he should save the manager from reading unnecessary words.

Copies of the marked articles or extracts are handed in to the manager's secretary, who reads them and eliminates what he knows would not be of special value. On one day each month the secretary has two hours in which to read the best articles or portions of them to the manager.

This manager is now considered a business genius. His firm is far ahead of all competitors. And he calls this plan, "a tickler to my creative imagination."

Irrigation and Sanitary Development in Argentina.—A bill is before the Congress of Argentina authorizing the construction of irrigation works to cost $20,000,000. The Ministry of Public Works also is reported to be considering a scheme for installing water works in every town of 3,000 population, and sewerage in towns of 8,000 population.

Square Dealing, a Bonus System, and Improved Equipment Triple Production

If the first factors of the above title lack novelty, at least the result stated warrants attention. In the "Iron Age" of Sept. 25, Mr. C. E. Wright gives a brief account of how these factors were handled, and the result secured in the foundry of the Bullard Machine Tool Co., at Bridgeport, Conn. Mr. Bullard's article bears the title, "Efficiency Methods Triple Foundry Output." The author says:

The foundry of the Bullard Machine Tool Co. was purchased early in 1917 from the J. A. Taylor Foundry Co., which had been making castings for Bullard machine tools, and the "maxi-pay" plan was shortly afterward put into operation. At the time the foundry was operated by the Taylor company, the average output of castings per man was 340 to 360 lb. daily, while the present daily output averages 1180 lb. per man. It would not be quite true, perhaps, to say that the system itself has increased the output to that extent, but the management gives the plan credit for a good share of the increase, and the other efficiency methods which have been introduced from time to time have helped to bring up the average production.

During the first few months of operation by the Bullard Machine Tool Co., but before the "maxi-pay" plan had been introduced, the foundry was turning out about 740 lb. daily per man. Since the plan was inaugurated, however, the average has not fallen below 1020 lb. per man daily, while present output is on the basis of 1180 lb. per man daily. The highest point that has been reached in any week was 1360 lb. per man, and while this was exceptional, it is not unlikely that it may be reached again under favorable conditions.

The Bullard "maxi-pay" wage and production bonus plan provides for bonus payment for increased production in addition to the hourly class rates. It is in no sense a piece-rate system, as the men are paid the hourly rate whether they become entitled to the production bonus or not. However, a man whose efficiency persistently fell too far below a fair standard of work would not be regarded as a capable workman and his services would eventually be dispensed with. Every opportunity, however, is given a workman in the way of instruction and the personal assistance of his foreman to make good before final judgment is passed.

Under the production bonus plan, a standard time for each operation is first established. The standard time is, in all cases, the time in which the operation can reasonably be accomplished. Standard times remain unchanged for one year from the date when they are established, provided no change is made in designs, method or equipment. Such changes, if made, are as equitable both to the foundryman and the company as it is possible to make them. A standard time, once fixed, remains unchanged unless it develops that it is unjust to the man. Then adjustment is made. The company takes the risk of having the standard established too high, but every opportunity is given in the trial time for establishing an equitable time before the final establishment of a standard time.

On new work, or old work done in new ways or with different equipment, it is not always possible to establish an equitable standard time, without actual experience as a guide. In such instances a trial time is set, and the operation performed thereunder until it is determined what a fair standard time should be.

Standard times are reckoned as 100 per cent; bonus payments, however, start at 75 per cent. That is, if a man achieves a 76 per cent record he is surpassing the point of inefficiency by 1 per cent. A production bonus of 1 per cent of wages is paid for each per cent of efficiency over 75 per cent.

If a man performs his work in standard time he would have an efficiency of 100 per cent, and therefore, is entitled to and receives a production bonus of 25 per cent. Thus, if a man averaged 100 per cent, throughout the month, and his hourly rate was 75 ct., his total wage, including his bonus, would amount to $1 an hour.

It is not to be expected, however, that a workman's efficiency will be the same on one day as on another. His condition of health, the weather or other things may cause him to lose production on some days, while a change from one kind of work to another, with which he is less familiar, is also a contributing factor to loss of production. The fact that the Bullard foundry makes from 3000 to 4000 different castings makes it almost impossible for every man to work continuously on one piece of work that would give him the exceptional speed which comes from constant repetitional work.

An actual record of one workman's efficiency during a month shows that for the first three days he was 93 per cent efficient; on the fourth he dropped to 89 per cent; then on the fifth day, he went up to 100 per cent; 99 on the sixth; 93 on the seventh; 105 on the eighth, and then his record fluctuated from 80 to 90 for about a week, when suddenly it dropped to 67 per cent. Whenever a man's work falls off that much an investigation is made the following day. In this instance it was found that workman's low record was due to a change of work. His unfamiliarity with the new work caused the low record. The second day on the new job, however, he gained to 71 per cent; then up to 77 per cent and the following day he achieved a 97 per cent record. For several days thereafter he fluctuated between 85 and 89 per cent.

It is not unusual in the Bullard foundry for a workman to go over 100 per cent. On one day recently a workman had a record of 114 per cent. It seldom goes higher than this, however, as too high a record would show that something was wrong with the standard time which had been set for the job. If such a mistake should be made, as it is occasionally, the men are as quick as the management to see that the trial time should be changed, and this is done without causing any criticism.

To show what has been actually accomplished on different foundry operations in the way of time-saving, it is cited that the bed for a 24-in. vertical turret lathe formerly took 28 hours to make and now is made in 14 hours, a saving of 14 hours. A part of this saving is due, of course, to new and better equipment which has been installed. The management estimates that possibly one-half to two-thirds is due to equipment and the remainder to increased efficiency among the men.

The men recognize that the company intends to be fair with them in all matters, and this attitude of the employers with its thorough understanding by the men is no doubt responsible for the fact that the Bullard foundry has been entirely free from strikes or labor unrest of any kind. The men are paid for all molds, good or bad, but of course a man who persistently turned out bad molds would be recognized as a poor workman. Allowance is made for mistakes, however, and the men are not penalized. If a man should lose time, through no fault of his own, such as a broken crane, proper allowance is made so that he does not suffer because of that interference with the orderly progress of the work on which he may be engaged.

One thing which has contributed greatly to increased efficiency in the Bullard foundry is the insistence of the management that skilled men should do only that work for which they are paid, and that common labor should be left entirely to men hired for that purpose. Core makers, for instance, are not permitted to put cores into the ovens. There are unskilled men who do that work, and the minute the core makers finish one core they begin on another.

The night men clean up the foundry and put it in good shape for the day gang. Thus, there is no pick-up work for the day men to do. Everything is in readiness for them, and they can start at work immediately when the gong rings in the morning.

The time of the men is saved in every possible way. Drinking fountains are placed at every convenient spot in the building so that a workman is not obliged to walk from one end of the foundry to the other to get a drink. These fountains are of the sanitary type and have proved very beneficial. Electric fans are also placed throughout the foundry so that on hot days better circulation of air is provided. Shower baths are used by the men when they have finished their day's work. Also metal lockers are provided for their clothes.

In metallurgical processes, the Bullard foundry department has also worked toward the highest possible efficiency. Its castings in nearly all cases surpass the 21,000 lb. per sq. in. requirements for tensile strength of the American Society for Testing Materials for medium castings.

POWER AND PUMPING SECTION

This section of the Waterworks and Hydraulic Monthly issue of Engineering and Contracting is devoted to the selection of power and pumping equipment and the economic management of its operation.

Selection and Operation of Power Plant Equipment

Although civil engineers and superintendents of pumping plants are rarely qualified to design power plant machinery, they are repeatedly called upon to select such equipment, install it and manage its operation. It is with this fact in mind that we select and edit articles for this section of Engineering and Contracting. The following article, although prepared by a committee of the Association of Railway Electrical Engineers, contains information of value to civil engineers and superintendents having charge of pumping plants.

Design and Installation of Plants Less Than 1,500 Boiler Horsepower Rating.—Plants of this size cannot afford the overhead of as many labor saving devices as those plants of larger size. However, there are a few of these devices that may be used, according to the size of the plant.

Any plant having a capacity less than 1500 boiler horsepower rating cannot economically use water tube boilers. The first cost is too high, and the labor cost necessary to keep the boilers in first class condition is prohibitive. The horizontal return tubular boiler is comparatively low in first cost, easy to operate and maintain, and withal, it is hard to find its equal in small plants as an economical steam producer when installed in conjunction with a properly designed furnace.

These boilers should be suspended from lugs rather than set on them. The longitudinal seams should come well above the fire line, and transverse seams should be kept well back of the bridge wall. The units should be of such a size as to give flexibility and with it, economy. The 72 in. by 18 ft. horizontal return tube boiler of 150 horsepower rating meets all of these requirements. But be sure that after a good boiler is obtained, it is not handicapped by providing a poor setting for it. It should be set not less than 42 in. above the grates, and a combustion chamber built large enough to burn the gases. The bridge wall should be built with at least 14 in. clearance between it and the shell of the boiler, and the bridge wall built vertically downward to the combustion chamber floor. Do not build a toboggan slide from the bridge wall to the combustion chamber floor, because of the decrease in volume thereby. The back wall should be built at least 3 ft. from the end of the boiler. This allows plenty of room for the gases and plenty of room for the workman when the boiler has to be re-flued. With 3 ft. of space it will not be necessary to pull down the rear wall when working on the flues at the back end.

The flat suspended tile arch over the back end has given best satisfaction. It relieves the side and back walls of outward thrust, which is common to the old arched type of construction. With the flat arch, the thrust is all vertically downward on the side walls. About 1½ in. clearance should be allowed between the arch and the rear end of the boiler when setting up. Fill this space with loose asbestos and then the worry over expansion is eliminated.

Build the side walls with plenty of clearance up to the closing-in point (2 in. above the top surface of the top row of flues), so that every square inch of water heating surface will be effective. Put on a good cast iron flush front and stay the setting with a few buck stays and through rods. Cover the brick work with a plastic material that will not crack under the action of heat.

Usually air or steam was originally used for blowing. The smoke box doors were opened up, and the hand lance inserted in each flue at a time. Sometimes it was run back through the flue and sometimes it was not. It was a dirty and disagreeable job at best, and one that had to be done when the load on the boilers was light. Just how often it was actually done was a question.

Mechanical soot blowers for horizontal return tube boilers are of two kinds. The rear end blower and the front end blower. The former cleans the tubes by blowing with the draft which is good. However, it sets in the back end of the boiler where the temperatures are high. True, it is supposed to be pulled back into a recess after using, where it is out of the direct path of the hot gases, but should the fireman neglect to do this the blower would be burned up, and the boiler have to be shut down for repairs. But suppose the blower was pulled back where it belonged. If operating anywhere near the economical point, the temperature at the back end is high, whether it is in the direct flow of the gases or out of them, and the blower subjected to this high temperature is bound to burn out in time. Also any water blown on the tubes will cause the fire combustion ash to clinker, completely closing up the tubes in time.

The front end blower is fastened to the smoke box doors, and cleans the flues by blowing against the draft, just the same as the old hand lance. But owing to the lower temperatures, the blower can be installed so that its blowing elements are much nearer the flue than in the case of the rear end blower. Also, the temperature at this point should be sufficiently low (if the economy is good) to give little if any trouble by burning out the blower, but in case trouble should occur it is not necessary to shut down the boiler to make repairs to the blower. As soon as the load falls off sufficiently, open the smoke box doors and make repairs. The flues can be blown at any time during the day, irrespective of the load conditions, with comparative ease and cleanliness to the operator.

In installing mechanical soot blowers, be sure that drain valves are placed after the main shut off valve, to be assured that no water is blown upon the flues.

Some success has been obtained by bricking up the combustion chamber clean-out doors. The brick can be torn out easily and replaced at each cleaning of combustion chamber, with little expense. The gain in so doing is two-fold. First, interleakage of air is prevented, and second, a uniform brick wall is presented to the impact of the gases, and no portion of them is cooled by radiation through the cast iron door.

Boilers should never be set with more than two in a battery. One division wall is enough expense to maintain.

In plants where the load requirements do not exceed 20 to 100 boiler horsepower the locomotive type boiler or the vertical boiler may be used. There are two important things to remember in connection with the installation of either of these type of boilers. First, provide plenty of ash pit space. This is for two purposes: To allow plenty of room for the admission of air and to provide storage space for a few hours run of ashes. More grates and mudrings have been burned out because ashes piled up against the grate and mudrings, particularly on vertical boilers, than for any other reason. The second thing to remember is that all boilers of these types should be properly lagged with some good insulating material.

For every 100 sq. ft. of radiating surface, 260 lb. of coal can be saved every 25 hours by lagging with 1 in. thickness of manganese. A 48 in. vertical boiler has just about 100 sq. ft. of radiating surface. A 36 in. vertical boiler has about 65 sq. ft. of radiating surface.

In general, each individual plant will have its own peculiar problems of design and operation, and such design should consider the exact kind of fuel to be burned, and furnace design in particular should be governed by fuel conditions. Unfortunately, however, in hand fired railroad stationary plants, the design of furnaces cannot be arranged for a particular kind of coal, but on the contrary, installations must be such as to burn any kind of coal that is delivered to the railroad. Therefore, it is poor engineering to design a plant to burn a particular grade of coal, and burn it most efficiently, and then discover after the plant has been put in operation, that the ever changing fuel conditions have made the price on a particular grade of coal almost prohibitive, and in order to use a more economically available coal, a change in the design must be made or continue to burn the high price fuel at a considerable loss. Therefore, plants of the size under consideration should be designed to burn all grades of coal with average economy, be it slack, mine run, chute droppings, or engine lump. This can be accomplished by setting the boilers high and building a roomy combustion chamber, and installing suitable grates.

The question is, just what are suitable grates? There are on the market today about as many different kinds of grates as there are plants. There are the stationary, the shaking, the rocking, the dumping, the semi-cleaning, the self cleaning, the so-called semi-automatic, and a great number of others.

What is the function of a good serviceable grate? A grate is merely a rack or series of racks on which the coal is placed and held during its process of combustion. Necessarily when the coal is burned, the ash and residue must be cleaned from the grates, whether it be manually with a slice bar and hoe, or mechanically through a series of hand levers and bell cranks. Further than this, a grate must be of such design as to allow a uniform distribution of air to pass up through it to continue the process of combustion of the coal. Thus a boiler plate punched full of holes would make a grate, but it would not make a good grate. The air spaces in a good grate must be small enough to prevent the dropping through of fine or slack coal, yet they must be of such design that they will not become clogged up with clinker and ashes. The grate must be of such design that under normal operation, and occasional abnormal operation, the maintenance cost will be low. Also it must be easy to repair, for no plant can afford to shut down to replace a faulty grate bar.

An experienced stationary fireman does not like a dumping grate. He would rather wing over his fires and clean them through the firedoors, and many times this is exactly what he does on a dumping grate. A rocking grate is to be recommended provided the grate bars do not lift too far up into the fuel bed, in which case the fuel bed will be torn up, and the ash and coal all mixed together, which is bound to give trouble by clinkering. The committee has in mind a plant where an interlocking finger grate was installed, which gave considerable trouble, until the engineer reversed every other grate bar, turning the fingers all one way, put a stop on his shaker bar arm so that the grates could not be thrown to a full open position. Today that plant is burning coal with good economy, and there hasn't been any expense for grate repairs in several years; because the engineer did away with the patented idea, which was theoretically good, and applied common sense to the problem. The problem is to decide upon some good, simple and common sense grate. If the open market is not able to furnish what is required, it can be made at foundry price.

Steel stacks for the smaller size plants are to be considered a better investment than either a brick or concrete stack. There is much in favor of separate steel stacks for each boiler, or for each battery of two boilers. With such installations there is no need of worry, whether the stack is large enough for additional boilers. It also eliminates trouble with breechings, etc. In general, it might be said that for plants having more than six boilers, it would be good design to use a common stack. However, with plants of six boilers or less, separate or battery (two boilers) stacks are recommended, but in any case build the stacks at least 100 ft. high, for it is easier to reduce the draft with a damper than it is to increase it with a steam blower.

Each boiler, whether having its own stack or connected to a common stack, should be equipped with a damper, and a device for controlling the damper. This device does not need to be more than a light ½ or ⅝ in. round rod, operating on a quandrant from the front of the boiler.

Care should be taken in the selection of boiler fittings. Since service is of first consideration, the first cost of such fittings should not be given too much weight in the selection. Valves that are easily repaired and give the best service for all conditions, should be the ones selected, and usually such equipment is not the cheapest in first cost.

The piping should also receive careful consideration and due allowance always made for expansion. Boiler nozzles should be connected to steam headers by steam loops of easy bends, and should enter the header at the top. Steam lines taken from the headers for various points of distribution should also connect to the header at the top with a loop of easy curvature. Blow-off valves should consist of a good grade of extra heavy cast iron, or cast steel. Two valves should always be used for blow-off service, one as a holding valve and one as a blow-off valve.

Feed water heaters should always be of the open type, in which the water is allowed to rain down over trays, with the exhaust steam rising up in the opposite direction. There are several advantages in this type of heater.

(1)—It is not a pressure vessel, or at least not one of high pressure.

(2)—The steam and water are brought in intimate contact, thus eliminating loss of heat through conducting surfaces such as are found in closed heaters.

(3)—The steam for heating is condensed and is pumped back to the boilers. Thus the amount of scale forming compounds is reduced.

(4)—They are easy to operate and maintain.

Precautions must be taken, however, to prevent an excess of pressure in the heater. This can easily be taken care of by an overflow loop, which not only acts as a pressure relief and safety valve, but also as a positive overflow device. This loop is simply a pipe coil connected to the heater the top of which is on a level with the overflow point in the heater. It extends vertically downward for 6 or 8 ft., turning upward again to the overflow level, and then downward to discharge into a sewer connection. The total length of the loop does not have to be such as to balance the safe pressure in the heater, but of a convenient length. The principle of the loop is that of a column of water, plus the friction of this water in motion (or surging) balancing the heater pressure. A small ¼ in. pipe in the second bend will prevent the loop syphoning all of the water out of the heater, acting as a vacuum breaker. This device can also be used on the oil trap and at other places on the low pressure or exhaust header where it is desired to drain the water from the line.

To overcome difficulties sometimes encountered with trapped air in the heaters, it is only necessary to run a ¾ or 1 in. pipe directly out the top of the heater. This pipe can extend through the roof, but should contain no valves or other connections. It will act to bleed entrapped air from the heater and will also act as a vacuum breaker.

Besides the cold water connection to the heater, provision should be made to take the discharge from steam traps into the top of the heater. Vacuum pumps should also discharge into the top of the heater as well as cooling water from the air compressors. Every bit of condensed steam returned to the boilers reduces boiler washing cost, and efforts should always be made to return all drips and drains to the heater wherever practical.

Boiler feed pumps should always be installed in duplicate, for upon the continuous feeding of water into the boilers depends the entire operation of the plant. Steam economy in boiler feed pumps is a questionable saving in any railroad plant. The old duplex pump is always reliable and understood by everyone, and so far as plunger pumps for boiler feeding is concerned, the duplex is to be recommended. Of course, the ideal boiler feed is the centrifugal pump, which will some day entirely supersede the plunger pump for many classes of service.

The most economical coal handling system for plants of this size is an overhead track or high line, using dump bottom cars discharging into a storage bin. The floor of the storage bin should be inclined so as to deliver the coal to the fireman in front of the boilers, without rehandling. In plants under 500 boiler hp. rating, the wheelbarrow is about the most efficient ash handling system. Steam jet ash handling systems may be considered in plants of greater capacity.

Air compressors for this size plant should be of the two-stage engine driven type. In cases of compressors 2000 cu. ft. capacity or over, the compound steam end is recommended.

Electrical generating equipment may be either reciprocating engine driven or steam turbine driven. For a railroad plant steam turbines are particularly adapted. The low maintenance cost on turbines, and the large amount of exhaust steam required for the winter heating season makes the high steam consumption of turbines an advantage rather than otherwise.

Where the generation is direct current, 250 volts should be used, and when alternating current, 440 volts, 3 phase should be used. Alternating current generation is recommended, the amount of direct current required being easily obtainable with motor generator sets.

An exhaust heating system is one of the most important and economical parts of those stationary plants which are located in the central and northern territories. It is a device or system that is included in the steam using equipment that raises its efficiency from 8 to 80 per cent, and yet an exhaust heating system improperly installed, or improperly maintained, can become the source of much trouble, and the cause of much loss. A well designed exhaust steam heating system will not require more than 2 to 3 lb. back pressure to operate, and will return condensed water to the boilers to the extent of over 50 per cent of the total water required. However, it is necessary that the exhaust header and mains be sufficiently large, that the heating coils be properly placed, and the return lines be so located as to make repairs easy, with vacuum traps in good working order at all times. It is well to bring the returns back to the power plant separately from each department, so that trouble can be quickly located by isolating each department, as required, until the trouble is found. Cut all exhaust available into exhaust header. It has even been found that vent pipe from wash out system can be cut into exhaust header through reducing valve to good advantage.

Vacuum pumps should be large enough to take care of the coldest season, and should always be installed in duplicate.

See that all steam (high pressure and low pressure) and air lines are covered. See that covering exposed to the weather is again covered with roofing paper and painted. See that all parts subject to any great amount of undesirable radiation is carefully insulated. Build a real plant to start with, and see that it is 100 per cent before it is turned over to the operating department. Confer and co-operate with the operating men in the design and installation of the plant, and if they are provided with a 100 per cent plant with which they are satisfied, the result will be that they will do more towards maintaining and operating it at 100 per cent.

Design and Installation of Plants of 1500 Boiler Horsepower Rating or Over.—A plant of this size can well afford the overhead cost of labor saving devices, and some of the more refined power plant equipment.

The boilers should be of the approved safety water tube type, and of such size as to be flexible, and yet sufficiently large to keep the idle investment charge down to a minimum. For the average heavy back shop plant, the units should be of 200 to 350 rated boiler horsepower capacity. This type of boiler requires a brick setting, unless steel settings are used. The material for brick settings should be carefully chosen and only the best furnace brick masons should be allowed to build the settings. A boiler setting is an expensive investment, and unless the best care is given to the building of brick settings, they will crack and crumble, and in only a few months they will require rebuilding. Do not put an air space in the boiler walls with the idea that insulation will be obtained thereby. If space is desired between the fire brick and common brick to allow for expansion, fill up the space with crushed cinders, front end cinders, sand or other insulation.

Poorly built settings represent a great loss of money. Not only is the first cost of the setting almost entirely lost in such a case, but there is a continuous loss in fuel due to great inleakage of air. Further than that, there is a loss in boiler capacity due to inefficient conditions and loss of draft. After the setting is built, it should be entirely covered with a plastic cement, or other material that will not crack under temperatures to which the setting is subjected, and against time.

The question of soot blowers has not been satisfactorily answered with this type of installation, although many experiments have been made. With a plant of this size, usually the force is large enough to keep the tubes well cleaned by the hand lance, and the supervision is sufficient to see that the tubes are kept cleaned.

Stokers are one of the labor saving devices that a plant of 1500 rated boiler horsepower, and over can well afford. The question of the type of stoker cannot be settled by any fixed rules, for the available coal supply will fix to a great extent the style of stoker. However, the chain of traveling grate seems to be a stoker well adapted to the Middle West territory, and has given good satisfaction in a large number of plants. It is easy of operation and repair, and when the units are of such size as to give flexibility of operation, the inflexibility of the traveling grate is overbalanced by its advantages.

A well built stack is always a good investment for a plant, provided that the stack is of sufficient size and height to carry any overload that the plant may be called upon to deliver. Force and induced drafts have been tried with varying degrees of success, but natural draft with a well designed stack can be depended upon at all times. Each boiler should be provided with a damper in the connection to the stack or the breeching, so that the boiler can be easily drafted for all conditions of load. Such damper should also be provided with damper control that can be easily operated from the firing floor.

In plants of the size under consideration with stoker fired boilers, the coal should be delivered to the stokers from overhead storage bunkers. It can be unloaded from the car to these bunkers with either an overhead crane or a traveling bucket conveyor. With the latter device, the same conveyor can also be used for disposing of the cinders. The ash pits should be located in the floor below the fire room, and should be of sufficient capacity to run 12 hours without cleaning.

Operation and Maintenance of Plants.—Once the plants have been installed according to the design which will best suit the needs for continuous and economical service, it is up to the operating department to operate and maintain them economically. The following indicates just what is necessary in order to accomplish the desired result:

Keeping soot from accumulating on tubes and flues is one of the most important steps towards economical operation. Flues should be blown at least once each eight hours, and when boilers are down for a washout, flues should be thoroughly cleaned with a brush or scraper. In case of water tube boilers, the tubes should be thoroughly blown when the combustion space is cleaned. Men should get inside of the furnace and inside of the combustion chamber and blow this soot. Boilers should be blown down at least once each 8 hours and men coming on shift should test water columns and try cocks, and pop valves.

Practice feeding the boilers continuously, maintaining a constant water level. Regulate the draft with stack damper rather than ash pit doors, according to the load carried.

When boilers are down for a washout be sure that they are cleaned. Rattle or turbine the flues if necessary and scale the shell. Clean out the furnace, and combustion chamber. Clean off the bridge wall and clean out the smoke box. See that all repairs to furnace and combustion chamber walls and arches are taken care of. Be absolutely sure that the boiler is 100 per cent, before putting it into service. Repair blow-off valves and feed valves if necessary. See that smoke box doors and combustion chamber doors are air tight. Minor furnace and combustion chamber repairs can be made with plastic cement. A barrel of this material should be kept on hand at each plant. Air leaks can be stopped up with a plastic boiler covering. A barrel of this material should also be kept on hand at each plant.

Stacks should be painted with an approved stack paint at least once a year.

See that non-return valves are kept in working order, and that all valves are kept packed; painting valve stems with graphite and oil about once a week is a wonderful means of saving valve stem packing. If the insulation is removed from the piping to make repairs, see that it is replaced.

Feed water heaters should be cleaned frequently. The frequency of cleaning can easily be determined by watching the temperature of the feed water. This temperature should never be allowed to drop below 200°. Carry the water level in the heater at such a point as to keep a head of water on the pump at all times, but not so high as to cause the heater to overflow continuously. Don't try to operate the heater without a water glass or thermometer. Always keep a water glass on hand. Both of these are necessary for the intelligent operation of any feed water heater.

Feed water pumps should be repacked once every 30 days. This insures one good pump on the job all of the time. A defective feed pump may mean shutting down the plant.

Air Compressors and Power Equipment. Should have rods and bearings keyed up at all times. Do not allow compressors to run with bad intake and discharge valve. Such equipment needs a general overhauling every three to five years. Inspect water jackets on compressors frequently, for in bad water districts they will fill up with mud and scale very quickly. Indicate all engines and compressors frequently and take care of leaky and faulty settings as quickly as possible.

The exhaust steam heating system, unfortunately, is a part of stationary equipment that seems to be little understood and sadly neglected: yet it is the one big economical device used. It is a fuel saver if there ever was one. Any railroad exhaust steam heating system should operate with satisfaction on 2 to 3 lb. pressure—certainly, never more than 5 lb. One pound of exhaust steam has about 90 per cent as much heat as 1 pound of pressure steam at 125 lb. gauge pressure, and a well designed and well operated exhaust steam heating system will reclaim about 90 per cent of this, and the greater part of the other 10 per cent goes into the feed water. A vacuum of 5 to 10 in. of mercury should he sufficient to operate any railroad exhaust steam system, provided the return lines are tight and the traps are not leaking.

During the summer of each year all heating system traps and sediment chambers should be removed and cleaned. See that the return lines are all in good shape and air tight, overhaul the vacuum pumps, and this done, there is no reason why the system should not go through the following winter without trouble. However, should occasion arise where it becomes necessary to shut the heat off, even for a short time, be sure that all drains from the system are opened to the sewer to prevent freezing up of coils and lines, and keep them open after the heat is again turned on until you have thoroughly warmed up the system and conditions are normal. Then cut in the vacuum pump.

If loss of vacuum occurs, find out in what section the trouble lies, by isolating each section in turn, then test the pumps by shutting off the returns. The trouble will finally be found to be in the pumps or in some section of the system, such as the roundhouse, shops, office, etc. Having located the section, go over the return lines in this section, with a torch if necessary, for a torch is about the simplest method for locating leaks in vacuum lines. If it is not located in the return lines, then look for a leakage trap. This can be located by shutting the steam valve on each coil in turn. When the exact location of the trouble is found, remedy it at once.

See that all steam, air, and water lines and valves are kept in repair. Do not allow pipe covering to become ragged and fall off. Do not allow pipe line supports and hangers to become loose. Keep everything in 100 per cent condition. Keep boiler and engine rooms clean and painted. Do not allow temporary shacks, piping and scaffolds to stand after they have served their purpose. Put in the broken window lights, rehang sagging doors, and paint the walls, piping and foundations. Make the stationary plant a clean and desirable place to work in.

Special Fuels and Methods in Boiler Furnace Operation.—It might be well to touch upon the burning of oil, gas and powdered coal in stationary plants. Also to remark upon the use of force draft with hand fired furnaces.

Where oil and gas are in active competition with coal, they can be burned with very great economy in railroad plants. There are only a few places where gas is used, and it is not likely that natural gas will ever be used to any considerable extent in railroad plants. The fuel is readily adapted for domestic use and the domestic field is too large and the supply of gas too small to make this fuel very active for commercial purpose. It is, therefore, merely noted in passing. The burning of gas has many similar features to burning of oil. The introduction of air is always through the burner. The user would do well to accept any of the patented gas burners on the market rather than attempting to do any experimenting. The burning oil in furnace boilers has assumed a very great importance during the past few years, and the continual rise in price of coal is going to make oil an active competitor of coal in the middle western territory.

Steam seems to be the favorite medium of atomization, although low pressure air has been used with very good success. Any burner that will atomize the oil efficiently, with a minimum of steam consumption, will give economical results. There are about as many patented oil burners as there are patented grates, and, as in the case of grates, a home-made burner, constructed on common sense principles, will usually give as economical results as the high priced patented article. However, it is well to remember that oil can be burned, or rather used, more extravagantly than almost any other commercial fuel. The design of furnace has considerable to do with the economical burning of oil. The use of pre-heated air (air usually heated by passing through ducts in furnace and floor, side walls or arches) does much to increase the efficiency of oil burning furnaces. Using oil in return tube settings, care should be taken to direct the flame downward, for if the flame is allowed to impinge upon the boiler shell, particularly in the vicinity of a seam, trouble will always result.

The question of burning coal without smoke and the design of smokeless furnaces is always a live one. Smoke is usually an indication of inefficient operation. Notice we say "usually," for there are a number of instances where smoking was excessive, and the efficiency very high. However, smoke is a nuisance and should be overcome if possible without resorting to highly expensive equipment. The process of "white washing" smoke should never be resorted to except in extreme cases. Don't be fooled into believing that by turning large quantities of steam into the furnace or stack that the smoke is necessarily burned or the efficiency increased. This process merely dampens down the smoke. The problem of smokeless combustion merely involves the proper and right relation of air and unburned gases, and the maintaining of a sufficiently high temperature during combustion of the gases. The proper mixing of air and gases usually involves a secondary admission of air, and the maintaining of the sufficiently high temperature is usually accomplished by brick work in the form of secondary arches and bridge walls, wing arches and smoke arches. If secondary admission of air is used, great care should be taken to see that this admission is properly controlled, for greater damage and loss of efficiency may result from the improper use of secondary admission than without it. Also remember that introduction of smoke and secondary arches results in a loss of draft, and make due allowances. The question of "dutch ovens" is one of the first to arise in considering smokeless combustion of coal But, while "dutch oven" furnaces are recommended in some cases, there are many coals that will not give results in this type of furnace. Furnace temperatures with "dutch ovens" are always high, and with a coal, the fusing point of whose ash is low, extremely high furnace temperatures are undesirable, for they turn the fuel bed into a slag bed of a sticky plastic mass, which cuts off air supply, burns out grates, rends the patience of firemen and engineers and always results in lowered capacities and efficiencies. Keep the furnace temperature as high as is consistent with the fusing point of the ash, but keep the combustion chamber temperatures as high as you can get them. In other words, there are many places where, if the "dutch oven" arch was moved out of the furnace and into the combustion chamber, a saving of fuel and increasing of boiler capacity would be effected.

There is no doubt that forced draft will increase the capacity of any furnace, for it increases the rate of combustion. But, also, forced draft may become the source of great loss of economy, when used inadvisedly, for it is such an easy matter to blow great volumes of excess cold air up the stack. The maintenance of forced draft equipment is also an item deserving consideration. Furnace maintenance with forced draft will be increased.

To overcome the bad features of forced draft, go a step farther and install regulated, controlled or balanced draft. There are several such systems on the market at the present time, and in choosing any one of them be sure to analyze the system completely. First of all there are two points to consider as the basis of regulation: the load conditions, and the furnace conditions, of which the furnace draft is an indication. All of the controlled forced draft system admit of the steam pressure as a point of regulation for load conditions. This regulation is obtained by a pressure regulator which speeds up or slows down the fan, accordingly, as the pressure drops or rises. As for the second point of regulation, the furnace condition is primary. There is no other condition, or set of conditions, that will serve as good a point of regulation basis as the furnace conditions. So in choosing any of the controlled or balanced draft systems, be sure that:

(1)—The furnace is used primarily as a basis of regulation.
(2)—The control device is simple mechanically and the maintenance not excessive.

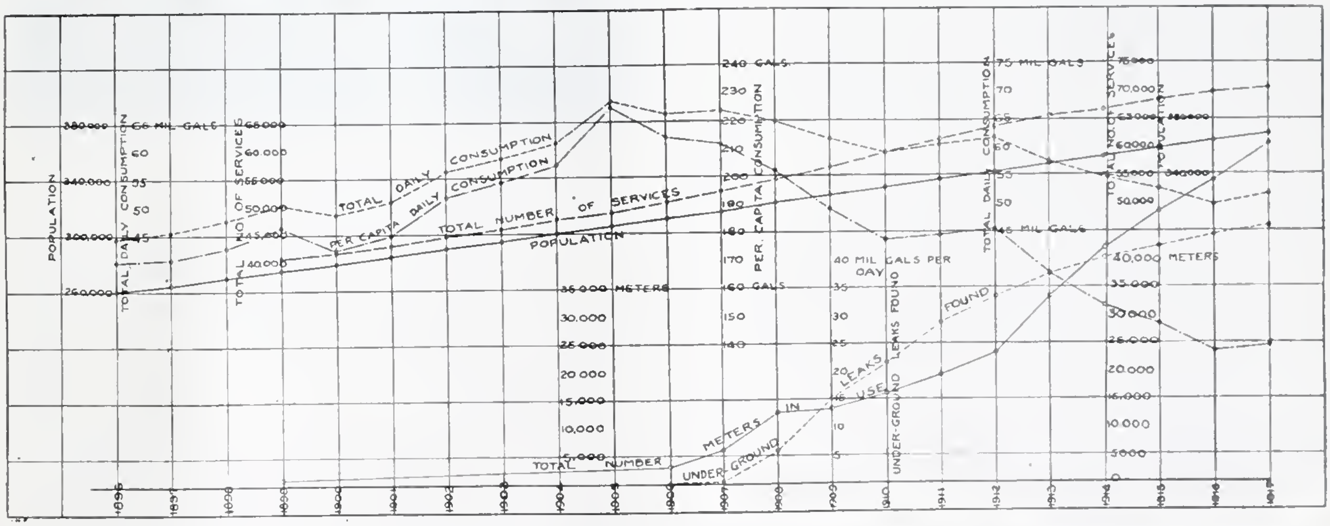
Brazil Considering Irrigation.—President Pessoa of Brazil in a message to the Brazilian Congress, recommends the undertaking of extensive developments. He suggests that the federal government be authorized to arrange either foreign or domestic loans for the purpose.

Some Details of Water Waste Prevention Surveys*

By PAUL LANHAM,

Engineer in Charge of Waste Prevention, Water Department, Washington, D. C.

Leak Detection Crew Prodding for Main.



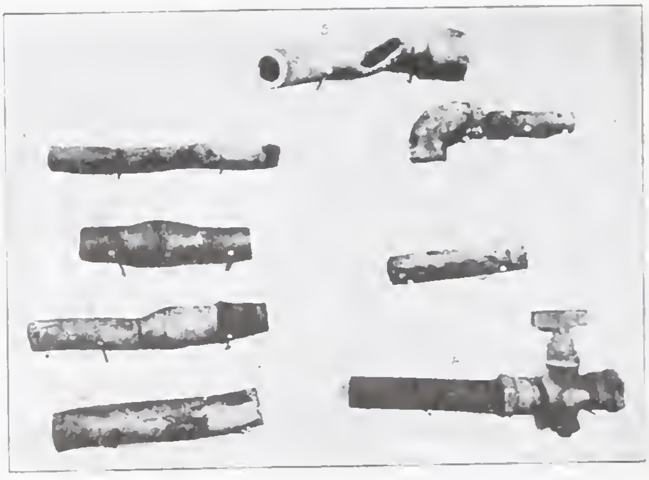
Water Consumption, Services, Meters, Etc., at Washington, D. C. Shows Rapid Decline in Consumption Due to Meter Installations and Waste Surveys.

The first and probably most important step in starting a water survey of a city distribution system is the proper division of the mains into permanent districts. This necessitates a thorough study of the general layout and some knowledge of the direction and rates of flow in the different trunk mains. These latter facts may be easily determined by using portable pilot tube apparatus at various points. In selecting boundaries for the various permanent districts it must be borne in mind that measureable velocities are necessary at the proposed district measuring points, that valve closures must be made at neutral or nearly neutral flow points to avoid serious interference with pressure and supply, that subsequent work makes the segregation of like consumers in the same district not only desirable but almost necessary, that ample capacity must be provided in mains feeding the district when other mains are closed off during the measuring periods, and that the districts must be of such size as to permit a complete detailed survey within a period of one or two months to avoid confusion of data due to changes of season while the work is in progress. These points cannot of course be literally carried out in all cases.

From four to six measurements of at least seven days' duration should be made if possible of the flow into each district each year. Portable recording pilot apparatus, which must be used upon the detailed flow analysis within each district is ideally adapted to these measurements and its use for both purposes simplifies the equipment considerably. These measurements give mean daily consumption, maximum, minimum and night rates of flow. Population count made by the inspectors while making the detailed surveys within the districts permits the district per capita rates to be determined. The per capita rate and the ratio of the night rate to the mean daily rate of flow are excellent indices of the condition of the district. Of course consideration must be given to the character of the consumption when reaching conclusions based upon these figures. To facilitate this, a census of buildings is also taken during the progress of the detailed surveys and this data, together with all other, must be recorded permanently for future reference.

Small temporary test districts are isolated after 11 p. m. and the total rate of flow into them observed and recorded on the pitot chart. Work of testing and inspecting is continued through the night up until about 4 a. m., when it is found that the rate of flow becomes unsteady and interferes with the tests. Tests are made at this time because legitimate consumption is then at a minimum while leaks and wastes will still be running at full head. In residential sections the rate during these hours is practically 100 per cent illegitimate.

The method of test consists simply of measuring the rate of flow into a limited number of squares and noting either the increase or decrease in this rate caused by altering the number of squares included in the test district. By "squares" is meant each section of the main in a given street lying between adjacent intersecting streets. In most cities valves are placed at these points. Of course the location of valves really determines the extent of the main included in each separate test. To go into detail, assuming a rate of flow of 100,000 gal. per day, for instance, in a test district of two squares, the rate of flow increasing to 110,000 gal. upon the addition of another square indicates of course that the rate of flow into this additional square is 10,000 gal. daily or the difference between the rates before and after its addition.



Defective Service Pipes Found by Water Waste Surveys.

No. 1—Corroded iron service. No. 2—Defective wiped joint. No. 3—Lead pipe damaged by bad workmanship when wiping joint. Nos. 4 and 5—Frozen lead pipe. No. 6—Corroded thread causing disconnection of iron service. No. 7—Electrolysis of iron pipe. No. 8—Broken stopcock due to abusive use of curb key.

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*Abstract of a paper presented Oct. 3 at the 38th Annual Convention of the New England Waterworks Association.

The method of adding squares is preferable as it keeps the size of the district under test always at a minimum, thereby facilitating the work by frequently excluding for longer periods undesirable fluctuation in certain squares, also by immediately locating this fluctuation upon its appearance upon the chart coincident with the addition of a square under test, permitting the immediate exclusion of this square to avoid its interference with other tests.

The usual method in preparing for the addition of a square is to close the valve at the far end first, which cuts off the only remaining feed, test the shut-off by opening fire hydrant or other fixtures, and then open the valve at the near end of the square. In cases where the water cannot be cut off the near valve is opened first temporarily destroying the isolation, permitting water to flow into the test district through this opening until the valve at the remote end of the square is closed. The recording apparatus for this testing work should produce a chart visible at all times, have a rapid chart movement and be quickly responsive to the smallest changes in rate of flow.

The locating of the night flow first involves the use of all street valves and when the flow is definitely determined as to quantity and location within the closest limits permissible with these valves, recourse is had to the aquaphone or waterphone and the operators listen with it on each curb stop-cock; fire hydrant, lawn sprinkler connection, or any other fixtures attached to the main within the pre-determined limits. Examinations are also made of all sewer manholes, large sewers, electric or other ducts. Flows due to fixtures or other causes within the houses or buildings are readily determined when the aquaphones are placed against the curb stop-cocks and the operators hear the flow passing through the pipe.

It is frequently necessary to drive test holes down to the mains and service pipes to permit the use of the aquaphone in definitely locating an underground leak within closer limits than provided by the valves, stop-cocks or other fixtures, increasing loudness at the different points indicating that the operator is nearing the leak. Frequently water or mud will be observed on the end of the steel prod used for this purpose and this indication is utilized.

The organization of a properly balanced force to efficiently handle the water waste problem is a matter depending considerably upon local condition. In general, the force should be supervised by an experienced engineer with at least one clerk and one draftsman comprising the overhead organization and as many field parties as the circumstances demand. Each field party should consist of a chief operator and two or more inspectors with necessary laboring force to clean out stop-cock boxes, open necessary excavations, operate valves and perform other necessary miscellaneous duties. At least one laborer is required for each inspector and of course more will be required if many leaks are found.

In Washington, D. C., over 45,000,000 gal. daily underground leakage has been stopped in the past 13 years. In another city over 2,000,000 gal. daily was the result of only one year's work by a single field party.

Points to Be Considered in Investigating Watershed Leakage

Useful suggestions for investigating the likelihood of watershed leakage, especially in small drainage basins such as are used for gravity water supplies, were given as follows by Mr. Robert E. Horton, in a paper presented at the last annual meeting of the New England Waterworks Association.

Watershed leakage is always from a higher to a lower drainage basin. In case of inversion, higher-lying adjoining areas should be examined. In case of diversion, the presence of lower-lying adjoining areas which may afford an outlet for the water losses should be looked for.

Aside from loss through solution channels in limestone regions, watershed leakage usually occurs only where there is a continuous ground-water horizon. It does not occur where there is an impervious rock barrier forming the boundary between the two areas in question.

Watershed leakage is more likely to occur between areas overlain by deep beds of sand, gravel or porous glacial deposits than between areas with less permeable soils or with rock near the surface. It is more likely to occur in regions underlain by limestone and sandstone than in regions underlain by shale or granite. It is more likely to occur through rocks of moderate dip than through horizontal strata—and it is more likely to occur through broken, seamy and fissured rocks than through compact, uniform beds of rock.

It is more likely to occur between basins with low, poorly marked watershed divides than between steeper areas. The configuration of the surficial ground-water table generally follows closely that of the overlying topography, and the topographic forms, as well as the geologic conditions, should be taken into account.

The shallower the soil mantle, and the closer to the surface the rock, the steeper the slopes, and the more impervious the soil and rock, the less is the likelihood of serious watershed leakage.

Lessons in Public Health Taught by Recent Experiences of U. S. Army

Some of the many valuable lessons taught by recent experiences in the United States Army are those pertaining to public health. Mr. Charles Gilman Hyde, Professor of Sanitary Engineering, University of California, in a paper presented to the October, 1919, meeting of the League of California Municipalities, outlines some of these lessons and summarizes them briefly as follows:

General Health.—Thorough-going physical examination, conducted at regular and reasonably frequent intervals, of all individuals in a community is of immense and far-reaching value in detecting defects and diseases in incipient stages.

Vaccination and re-vaccination of all individuals in a community to protect against such diseases as smallpox and typhoid will, in cooperation with other preventative measures, practically eradicate these scourges of the past.

Venereal disease should be subjected to early and continued treatment and prophylaxis and treatment stations should be generously provided.

A well-balanced food ration is fundamental to good health; therefore free public instruction in foods and diet should be provided in every community.

Regular, systematic exercise is also fundamental to good health; therefore public attention should be directed to this matter.

Personal cleanliness is one of the greatest possible aids to robust health and self-respect.

Crowding, especially in sleeping quarters, is dangerous and should be avoided.

In general, good health is absolutely essential to mental and physical efficiency and is significantly dependent upon faithful obedience to the laws of personal hygiene.

Greater attention should be given to the cleaning of all eating and drinking vessels and utensils in public places.

Water Supply and Sewage Disposal.—In view of the relatively very slight cost, of water disinfection, no community can justify the purveying of an unsafe, insanitary water supply.

Every community of considerable size, provided with a public water supply, should abolish latrines and privies, and introduce a modern water-carriage sewerage system with the proper methods of disposal.

Excessive amounts of grease in sewage render its treatment difficult, and its value justifies an attempt at salvage by large producers.

Refuse Materials and Their Disposal.—Municipal refuse contains many salvageable materials if proper classification at the source of sorting at some central point is resorted to.

Fresh municipal garbage is valuable as a hog food, and its use for this purpose may represent a profitable undertaking.

Poorly designed and constructed incinerators for mixed refuse are expensive and unsatisfactory to operate and have a short life; it is possible to design incinerators to operate without producing a nuisance.

Refuse dumps can be maintained in a sightly condition without nuisance but considerable expense for labor is involved.

Bank Revetment of Boulder and Fence Wire

By E. EARL GLASS, C. E.

This work was done to strengthen the low bank of San Antonio, Wash., where it enters the highly cultivated Pomona Valley. This torrential stream bed is typical of the Southern California "washes" with their watersheds, located in the abrupt Sierra Madre Mountains. At the mouths of their canyons, the streams spread over broad detrital cones where the shallow channels permit disastrous meandering, ofttimes through valuable orange groves and populous communities.

During about eight months of the year these washes are absolutely dry below the mountain canyons, any water reaching the mouth of the canyon being diverted in steel and concrete conduits to irrigate the farm lands in the valley below. But for a week or two, usually during the months of January or February, these barren stretches of gravelly creek bed become raging torrents and furnish the engineers of the Southwest a sizeable problem in flood control.

Anchor Post and Deflector.

Completed Bank Protection.

The method decided upon for confining the flood waters from San Antonio Canyon to the main channel consisted in reinforcing the low west bank with a hand-laid mattress of boulders and fence wire.

A rough masonry wall 3 ft. wide and 3½ ft. high was laid in the footing trench and where necessary the gravel bank was built up to uniform slope with rough stone. These were well bedded and covered with sand, after which 58-in. Type F, Elwood wire fencing was spread upon the trimmed slope and 10-gage tie wires attached at frequent intervals. These wires were raised to extend through the wall as the cobbles were laid up the slope. Then the fence wire was folded up from the bottom and stretched tight with a bar while the tie-wires were twisted securely. The slope face is 7½ ft. wide and the top of bank averages 5 ft. above the stream bed.

When the paved slope was completely covered with wire and all securely tied down, concrete posts 12 in. wide were cast at 25-ft. intervals to increase the stability of the mattress.

Boulder and wire rolls were placed along the footwall as wings to deflect the current from the protected bank.

Mr. Willis Jones was engineer on the work and the cost was born jointly by the county of Los Angeles and the interested property owners.

The length of the improvement is 2,810 ft. and the total cost, including engineering, was $8,100 or $2.88 per lineal foot.

School Children Raise Food Valued at $48,000,000.—Children enlisted in home gardening under school supervision in the U. S. School Garden "Army" have produced, in the little more than a year the work has been in operation, foodstuffs valued at $48,000,000, according to an announcement of the Bureau of Education, Department of the Interior.

The Drainage Problem from the Viewpoint of the Investor and Investment Dealer*

By EDWARD BOWER,

Of Otis & Co., Cleveland, O.

In the successful working out of the drainage problem, those primarily interested logically divide into three classes—the men who own the land to be drained, the engineers who prepare the plans and create the drainage system and the investment dealer, and through him the investor, who furnishes the money to pay for the operation. It is my firm conviction that the interests of all three are identical. I am very sure that when this whole matter is thoroughly thought out and studied and understood that this will be proven to be true. I believe that the effort necessary to bring us to this conclusion is worth all the labor involved in its accomplishment.

I am of the opinion that there is a considerable misunderstanding of the true attitude of mind of the investment dealer. His first concern must be absolutely the welfare of his client. If this is not so he will not remain long in business. His second concern is that of profit for his effort. Therefore he must see to it, if he handles drainage securities, that those securities are absolutely safe and sound; that his client will receive promptly at the agreed time not only the interest upon his principal, but also, without fail, the principal of his investment at maturity.

In our opinion the following elements are essential in the formation of a drainage district and the creation of securities to finance such undertaking:

First: The drainage laws under which the district is formed and in accordance with which the securities are issued must be absolutely right and air-tight, and such laws must have been litigated to the point of having the approval of the highest court. Such laws preferably should be general, and not special laws created for each occasion. We are very strongly of the opinion that the laws should be such that securities issued under them become essentially general obligations, so that all of the property in a given district is security for the bond issue as a whole, and not a specific part of a bond issue secured by a specific piece of land. The legal end must be so worked out that there is no difficulty in obtaining the opinion of a firm of bond attorneys of very highest standing.

Second: The soil in the given district must be of such a nature that when drained it will become highly productive.

Third: The population of the district must be large enough and the ownership of the land in the hands of such people that there can be no question about the levying of a sufficient tax, and the collection of the same, to meet the obligations incurred in the securities to be issued. There should be a real demand from such a representative part of the population and land ownership for the improvements as to produce a willingness to pay the tax imposed.

Fourth: There must be sufficient transportation facilities, or the assurance of the same, to carry the products of the district to market, as well as a knowledge that there is a real market for the things that the district will produce.

Fifth: The engineer's opinion, from our standpoint, is equally as important as the legal opinion. Unless the investment dealer can rely upon the reports of engineers in charge of drainage operations he certainly cannot afford to handle the securities. Not only must the engineering be properly and scientifically done so far as the specific district is concerned so that it will really accomplish the proper drainage of the district, but it must also take into consideration the districts lying contiguous thereto, so that at some future time the efficiency of the specific drainage system will not prove inadequate because of water being dumped from adjoining districts. From our point of view we believe it is essential not only that the officers in charge of a district shall employ reputable and competent engineers to create the drainage system itself, but that also they shall have employed a firm of consulting engineers that shall act as an effectual check upon those actually doing the work. There is always the possibility, in any undertaking, that those close up, because of their very nearness to the thing, may overlook some very essential factors which will be apparent to those more remote, and, for this reason having a more general view of the situation. Also, this practice has a strong tendency to instill confidence in the minds of purchasers of drainage securities.

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*Abstract of a paper presented Nov. 12 before the National Drainage Congress.

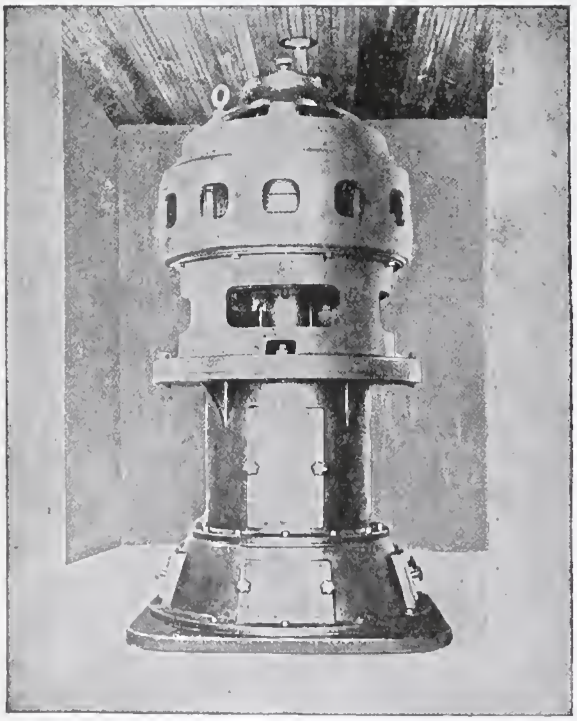
Sixth: Development of a high sense of business principles in the officers of drainage districts, the realization that the credit of the district is dependent upon the prompt performance of their duty. Our only difficulty in this respect has been the failure on the part of the officers of the district to remit funds for payment of interest and principal promptly, so that it would reach the depository of the district in time for prompt payment of coupons and principal. The application of strictly businesslike performance in this regard would entirely remedy this difficulty.

All of the six elements presented above must exist, and in the proper relation, in order to produce the things essential to the ultimate success of any drainage undertaking; namely, to bring about in the given district a large increased population, a smaller division of land ownership, greatly increased production, bringing about the realization of large profits and large enhancement in land value. Only in the accomplishment of this result will there be forthcoming ample taxes out of which principal and interest can be met. The achievement of this end spells success; the failure to achieve this end spells disaster.

New Motor Driven Pumping Installation of Savannah

The city of Savannah, Ga., has recently installed an electric-motor driven pump on an artesian well furnishing 4,000,000 gal. of water daily to the city, which is operated at a cost of $10 per 1,000,000 gal.

The artesian well is 519 ft. deep and was dug by the use of dynamite. A 24-in. casing was sunk to a depth of 110 ft., and from there to the bottom, a 16-in. casing is used. The pump, which is of the Layne & Bowler centrifugal type, is installed 100 ft. below the surface. It is driven by a 200-hp., 2-phase, 60-cycle, 2200-volt, 1175-rpm., vertical induction motor which was built by the Westinghouse Electric & Manufacturing Co., and shipped to Savannah from the East Pittsburgh works by express because of its urgent need by the city. Current for the operation of the motor, is supplied to the city by the Savannah Electric Co.



New Motor Driven Pump of Savannah, Ga.

Tests made on the water pumped from the well have proved its superiority over the water formerly pumped from the River station, and it is apparently much softer than any artesian water ever used in the city before. This softness is such that it does not strike a strata of lime. The water is said to have some sulphur, lather fully, and to be unusually well adapted for all domestic as well as commercial uses.

The pump was installed by P. D. Bowler of the Layne & Bowler Corporation of Memphis, Tenn., and motor and control were supplied through W. C. Bryant & Co., Westinghouse dealer in Savannah.

The total number of wells completed, or for which contracts have been let is five, to be driven by motors of the following capacities: one 100-hp.; two 200-hp.; one 250-hp.; and one 300-hp.

All the motors are installed above ground on all these applications except one which is located under the street in a pit entirely enclosed and furnished with forced draft ventilation.

Personals

Al. Wliiams of Ionia, Mich., has been appointed county engineer of Ionia County.

E. R. Treverton, an electrical engineer, has been elected city manager of Rock Hill, S. C.

Grover Shannon, civil engineer, has been appointed a member of the State Reclamation Board of California.

Fred E. Johnston, a civil engineer of Fort Smith, Ark., has been appointed city manager of Sallisaw, Okla.

E. A. Ward, division engineer of the Texas State Highway Department, has been appointed resident engineer of the Dallas (Tex.) Chamber of Commerce Metropolitan Development Association.

Matthew R. Riddell, until recently chief engineer of the Canadian Aeroplanes, Ltd., of Canada, has been appointed assistant professor of aeronautic engineering and assistant director of the Enginering Experiment Station at the University of Illinois.

Wm. W. McClendon, for the past five years city engineer of Mineral Wells, Tex., and Lieut. A. B. Purnell, have formed an engineering firm under the name of McClendon & Purnell, with offices at Mineral Wells. The firm will specialize in municipal and highway work. Mr. McClendon will still act as city engineer of Mineral Wells and Mr. Purnell will have direct charge of all outside work.

Russell W. Stovel, recently lieutenant-colonel of engineers, U. S. Army, has been appointed as a consulting engineer by the Westinghouse, Church, Kerr & Co., Inc., and will devote his entire time to the electrical and mechanical features. Mr. Stovel had direct charge of the Paoli and Chestnut Hill electrification of the Pennsylvania R. R. and the Elkhorn grade electrification of the Norfolk & Western R. R With the American Expeditionary Forces in France he served as chief of the terminal facilities division of the army transport service, one of the two big divisions of transportation of which Brig.-Gen. Atterbury was the chief.

Industrial Notes

H. B. Bushnell, engineer of maintenance for the State Highway Department in Illinois, resigned Dec. 1 to become associated with the Western Wheeled Scraper Co. at Aurora, Ill., in the capacity of consulting and sales engineer. Mr. Bushnell graduated from the University of Illinois in 1907. For the past ten years he has been associated with the Illinois State Highway Department in the capacity of assistant road engineer, district engineer and engineer of maintenance, with the exception of 18 months' service with the army engineers. Capt. Bushnell was overseas 13 months in charge of camp and road work.

The Standard Asphalt & Refining Co., with general offices at Chicago, has made arrangements with the Insulite Products Co., Inc., of Portland, Ore., to handle its products on the Pacific Coast. The Insulite Products Co. is a new company recently organized and will be managed by F. B. Gilman, formerly of the F. B. Gilman & Co. Mr. Gilman is well known on the Pacific Coast and has an experience of 22 years' standing in the asphalt and engineering field. They have opened general offices in the Railway Exchange building and are arranging for branches in Spokane, Tacoma, Seattle, San Francisco and Los Angeles.

Fairbanks, Morse & Co. will start erection next year on a foundry at Beloit, Wis., that will call for an expenditure of about $1,500,000. This structure will be 900 ft. long, 550 ft. wide and will contain 495,000 sq. ft. of floor space, including storage of flasks, iron, sand, etc., which will also be under the roof. It will cover 11 acres of ground. It will be located directly to the north of the present power house. The foundry will have an ultimate capacity of 350 to 100 tons of gray iron daily and will eventually employ 1,500 additional men, and 1,500 more men will be required in other departments of the factory to meet the increased production that will result.

The Asphalt Association, with main office in New York City, has selected Washington, D. C., as a district headquarters Maj. Harry D. Williar, an engineer of the First Division, will have charge of the Washington office, which will be in the Munsey building. Maj. Williar is a Marylander, receiving his training as an engineer on the State Road Commission and later wth the Paving Commission of Baltimore. At the outbreak of the war he entered the officers' training camp at Fort Myer and was one of the engineer officers selected to go to France with the original Pershing expedition. Included in the Washingtoin district are the states of Maryland, Pennsylvania, Delaware, Virginia and West Virginia.

The Chicago Pneumatic Tool Co. reports orders booked during the month of October in excess of any previous month since the armistice. The same is true of its English and German subsidiaries. While the German subsidiary was seized by the German government and has been run under "compulsory administration" since the United States participation in the war, compulsory administration has now been abolished and the management is being transferred back to the Chicago Pneumatic Tool Co. through the Courts of Commerce, according to cable reports just received from the company's representative, now returning from Berlin. Reports show the German company as well managed during the war and is now operating on a satisfactory basis. Arrangements have been made to materially increase production.

Railway and Excavation Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $3.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Is Labor Treated as a Commodity?

Socialists maintain that many of the evils of the capitalistic system spring from the fact that labor is treated precisely as if it were a commodity, the price of which is governed entirely by the law of supply and demand. Most labor unionists hold this belief also. Is it in accord with the facts?

In making a logical analysis of a proposition of this sort the first step should be to ascertain the differences, if any, between the things that are classed together. The second step should be to ascertain whether any of those differences operate to destroy or to restrict the given generalization in question. In this case labor is said to be treated under the capitalistic system precisely as if it were a commodity; and that therefore it falls within the generalization known as "the law of supply and demand."

That labor differs from most commodities is apparent. The "commodity" that labor most nearly resembles is a machine, for machines (whether of metal or of animal muscle) are capable of doing a great deal that human labor does. But a machine differs from a laborer in two important ways: First, a machine itself has no demand for its own product. Second, a machine can not, of itself, reduce or increase the supply of its own product. Of course both these differences between a laborer and a machine occur because the one has a brain and a nervous system which the other has not.

Having ascertained these two differences, the second step consists in determining whether the law of supply and demand as applied to machines applies with equal exactitude to laborers, since they are said to be mere machines under the capitalistic system.

Capitalists buy machines merely as instruments with which to produce the things that men want. Since in America most men fall within the class known as workers, we may say with substantial accuracy that capitalists buy machines in order to produce things that labor wants—clothing, food, light, heat, buildings, etc. This being so, if labor were merely a machine in the eyes of capitalists, we should have the anomalous situation of capitalists buying machines to produce products that the machines desired. To this it can be replied that capitalists are forced to give laborers a living wage, just as they are forced to feed horses a living ration, beyond which they need not go under the capitalistic system. This, however, is not true, for it omits consideration of one difference that we have already mentioned, namely, that laborers have control of their own output. If workers are not satisfied with their wages they can restrict their daily output, or they can cease to produce anything at all. While this last measure is spectacular, it is really quite insignificant in its total effect compared with daily restriction of output.

It is quite generally agreed among scientific managers that the average output of all

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

workers could be increased fully 50 per cent were they to work faithfully. So there is a loss of about twenty billions of dollars annually in America as a result of this daily restriction of output on the part of workers. In India the workers have for centuries made restriction of output a part of their religion as well as of their social customs. A Hindu born into a given caste can not change his caste. But what is a caste? Nothing else than a class of industrial, political and religious workers, the higher castes being those that direct or control the lower castes. In short, the caste system of India is the guild or trades union system carried to its logical conclusion, if it be the object to restrict the output of workers under the delusion that the capitalists will get all the output above a living wage.

The appalling poverty of India is itself the most eloquent refutation of the socialistic theory that capitalists treat labor merely as a commodity. If they were thus able to treat it, and if they were ignorant enough to do so, American capitalists would hold American laborers down to a bare living, even as the Hindu workers have held themselves down for centuries.

Intelligent capitalists, however, selfish they may be, have long ago learned that generosity toward their employes brings far greater profits than can possibly be secured by acting under the theory that labor is merely a machine to be bought only under the law of supply and demand. It is the laborers themselves, and not capitalists as a class, who foolishly seek to apply this "law" that classes them with mere commodities.

In India we see 10 Hindus doing the work that one American does, getting less than one-tenth the wage that the American gets. In Europe, for years prior to the war, we have seen two to three Europeans doing the work that one American did—taking farming, mining and manufacturing combined or separately. And we have coincidently seen the average American worker earning two to three times as much as the average European, measured not merely in money but in the things that money buys.

"Yes," replies the labor leader, "that it true, but our American labor unions have forced these high wages from the capitalists." If this is so, why haven't the trades unions of Great Britain forced similar high wages from British capitalists? Those unions are much better organized than American unions, as is well shown by their ability to restrict membership through the apprentice system and to restrict output. As a matter of recent history, it is well known that during the war the British unions grudgingly permitted the Government to set aside their rules restricting output, but only for the period of the war! It is also well known that women workers entered British factories and turned out two to three times as many units of product as the unionized men had been accustomed to turn out! Clearly, then, it has not been the strength of American labor unions that accounts for higher wages in America.

Labor leaders and laborers alike have been deceived by the increases in wages that they have secured through strikes and threats of strikes. They have fancied that they have wrested part of great profits from capitalists, that capitalists have enjoyed for many years. As a matter of fact, through invention and good business management, the output of workmen in America has been increasing every year. What the workmen have got has been nearly all of this increment. The small percentage of increment that they have not secured bulks large when in the possession of a few capitalists, and thus tends to create the impression that most of the increment has gone to capitalists. Had there been no increment in output, due to invention and improved management, American unions might have struck for higher wages as frequently as they used to strike in England before the war, and they would have "wrested from capitalists" just as little as their British cousins were able to wrest, for blood can't be sucked from a turnip.

We do not contend that labor unions have not forced many capitalists to pay them higher wages. We do contend that strikes have not been the principal means by which wage increases have been secured. We do not contend that the law of supply and demand has no effect in determining rates of wages. We do contend that this law has played only a minor part in America; and that where it has played a major part, as in India, it has been because the workers themselves have restricted output. We do not contend that American capitalists have been wholly unselfish. We do contend that they have often been altruistic, and that even where they have been selfish they have usually been intelligent enough to see that liberal wage payments lead to larger profits.

Why Not Confer a Vice Presidency on Railway Chief Engineers

Most railway companies have several vice-presidents, each in charge of different classes of executive work. The chief engineer is primarily an executive officer, and the department over which he presides is one of the most important of all. Why, then, should not the chief engineer of every railway be made a vice-president? If this were done his title might be Vice-president and Chief Engineer, or Vice-president in Charge of Engineering.

That this has not been done is largely attributable, we believe, to the fact that in the early days of railroading the chief engineer spent most of his time in field work, and was often more of a "detail designer" than a broad executive. This type of chief engineer is still to be seen on some of the smaller railways, but on nearly all the larger systems the modern type of executive engineer is found in control of construction and maintenance.

The executive engineer is necessarily a man who knows more about men than about technical details. However, his technical training enables him to weigh accurately the technical ability of his assistants. In addition, he is able to analyze their reports and grasp the full economic significance of their suggestions.

It has been said that the late James J. Hill did not hold engineers in very high esteem. Perhaps that explains why so many ambitious engineers left the Great Northern during his presidency. He succeeded in spite of his weakness in this respect, but his success would have been more pronounced had he shown greater recognition of the worth of engineering services.

Among civil engineers today the opinion is quite prevalent that no very attractive future lies before the technical engineer in railway service, even though he be extraordinarily intelligent and ambitious. This opinion is the outcome of years of scant remuneration and just as scant rewards of other sorts. It will be a sorry day for railway progress if this opinion becomes universal, yet that day is already on the calendar of the not distant future, and will surely arrive unless something radical is done to make railway civil engineers take heart.

Why Civil Engineer Should Call Upon Editors of Daily Press

The editors of daily papers usually attempt to express honest opinions about all matters that they discuss. Since each editor discusses nearly everything under the sun, he can by no chance be right all the time. If he is right 60 per cent of the time his "batting average" is fairly good, and he knows it. Knowing this, the average editor welcomes, rather than resents, a personal call from an intelligent specialist who undertakes to correct an editorial misapprehension. Why, then, do not engineers more frequently make personal calls upon the editors of daily papers? It is not because engineers never see editorials that they know are erroneous. It is probably because they feel that such calls will not be welcomed.

We believe that few editors will resent advice given in good faith by any expert. In any case, is it not the duty of engineers to correct mistakes made by editors even when it is known that the editorial ear will not be friendly?

We frequently see editorials condemning the action of public service commissions in raising street car rates. Why do not the engineers of such commissions go personally to editors and explain the data upon which commissions' decisions are based?

When an editor speaks in condemnation of a rate decision, he rarely has any real knowledge of the mass of information gathered and presented by both sides; yet he is habituated to express opinions and does so in the absence of facts. Go to him and show him a grist of facts. Make him ashamed, if need be, of his ignorance. Force him to admit his ignorance.

He will be a better editor thereafter, at least on one topic; and he will thank you for his gain in knowledge.

The Effect of the Government's Action in Discontinuing Piece Work in Railway Shops

When the government took over the railways, piece work was discontinued in many railway shops, and the 10-hour day was reduced to 8 hours. The politicians told us that man could do as much work in 8 hours as in 10, and that day labor work would be as efficient as piece work. How have their predictions turned out?

According to W. H. Atterbury, vice-president of the Pennsylvania R. R., the shops at Renova, Pa., have shown the following results since the government took them over: Change from piece work to day work reduced the output of the men 25 per cent. Change from 10-hour to 8-hour day caused a further falling off of 20 per cent. "so that the output per man per day in our shops is but 60 per cent of what it was before we entered the war."

Thus are the predictions of politicians verified. Now it takes 10 railway shop men to do what 6 formerly did.

Cost Plus Contracts

To the Editor: In your issue of Oct. 22 you published a short article upon a cost plus contract, which we are using in the construction of a dam which is now under way.

We note in your quotation of the comment published in the "Weekly News Letter of the Associated General Contractors of America" that reference is made to the danger to the contractor in an arbitrary delay of the work by the engineer, or his insistence upon a more costly procedure.

We believe that this danger does exist to a limited extent, but is not a serious objection to the form of contract. It is a matter of observation that under present conditions many of the engineers in local charge of construction work are less qualified by experience and ability than the contractors who are performing the work.

We believe that the unit price contract is, to a great degree, responsible for this condition of affairs and that a contract which lays more authority and responsibility upon the engineer will result, in general, in the retaining of higher grade men to handle the engineering on construction, bringing about a greater exchange of confidence between the contractor and the engineer.

As stated, however, in the quotation which you published from our previous letter, we will be better able to give a first hand opinion of this form of contract when the work being performed under it has been completed.

GANNETT, SEELYE & FLEMING, Engineers.
Harrisburg, Pa.

How Some Valuations Are Made

To the Editor: In June, 1919, I was asked to go over a short railroad line and make a rough check upon the valuation which had been placed on the property by a firm of consulting engineers. The appraisal was so erratic with some results so wide of actual replacement cost that I visited the firm's office and asked them to check over some results. While at the office the manager explained their method.

He employed assistants who inventoried property upon carefully prepared blanks. These men were spurred to accomplishment by a weekly published list of work of each man. Right of way was taken by the mile and its nearness to city noted. Selling price of land in vicinity was obtained. Buildings were classed and cubic contents taken.

Values were given lands by acre price, taking only width of right of way and length of line. Buildings were valued by cubic contents, class and a value curve. Track was valued by the mile, using three units, subgrade, ballast and track all from their previously developed table.

The lamest part of this job was the applying to an abandoned and dismantled power house the value curve of a like building in service and applying farm land value to land of no value which was donated.

One's regard for acumen of bankers is shaken when they buy such valuations.

A. M. VAN AUKEN.

Cost of Driving 8,700 Ft. of Tunnel by Station Men

In connection with the reconstruction of its canal system the Naches-Selah Irrigation District, comprising some 10,500 acres of orchard lands in the Yakima Valley, Washington, will construct 16 tunnels of an aggregate length of 21,000 ft. Eight of these tunnels, totaling 8,718 ft., were constructed in 1918 during war times. The tunnels are 7 ft. wide in the clear, with flat bottoms, side walls from 4 to 5½ ft. high to the spring line of a segmental arch with a 2 ft. rise. The reinforced concrete lining, except in the timbered sections is 6 in. thick, with the exception that in rock the floor thickness is 4 in. The tunnels were driven through soft and dry sand rock and shale, and in all cases but one the drilling was done with coal augers.

The tunnels were driven by station men, who in some instances were paid at the rate of $6 per lineal foot. Three men constituted a shift. The tunnel driving was doubled ended and double shifted. The station men netted from $10 to $15 per day, and at the same time set the pace for speedy, economical tunnel driving.

Method of Using Coal Augers.

The holes were bored about 8 ft. deep, usually 9 ft. on a face. No springing was required. The coal auger was held in place by being jacked against the floor and roof. Varying lengths of auger were used as the hole progressed. About an hour usually was required to drill and load the holes. The three men did the mucking, using large scoop shovels for this purpose. One of the three drove the loaded car hauled by a mule to the dump. The haul was short and took only a few minutes. An average of 20 lin. ft. per day was made on some of the tunnels driven in soft shale.

In the tunnels where sandrock was encountered, a little more time for drilling and more powder were required; but there was very little difference in the progress made.

In lining the tunnels, the floor was run in first, contrary to the usual practice, then the sides and then the roof. The mix for the latter was 1:3:5; for the floor and sides it was 1:2:4. The mixing was done outside by machines and carried in by cars on track. Four men in the tunnel, two taking turns shoveling overhead, and two, one on each side, tamping back into place, would ordinarily put in 60 ft. of roof in 8 hours. The maximum run was 70 ft. in 8 hours.

During most of the work labor was paid $4.50 per 8-hour day, and part of the time $5.50.

The following tabulation summarizes the cost of driving and lining the eight tunnels:

Tunnel No.	Length, ft	Cost Total.	Cost Per lin. ft.	Excavation cost. Total.	Excavation cost. Per cu. yd.	Lining cost. Total.	Lining cost. Lining per cu. yd.
1......	1,920.0	$ 40,695	$21.20	$18,173	$4.10	$ 22,522	$22.20
2......	782.5	18,949	24.20	9,353	5.20	9,596	22.80
9......	1,363.0	27,357	20.00	10,437	3.33	16,920	23.40
10......	1,080.5	21,293	19.70	8,445	3.39	12,848	22.30
11......	883.0	16,294	18.20	6,973	3.89	9,321	21.00
12......	893.0	16,047	18.00	6,285	3.51	9,762	22.00
13......	651.0	12,204	18.70	4,645	3.32	7,559	22.40
14......	1,145.0	22,468	19.60	7,162	3.13	15,306	27.20
Total...	8,718.0	$175,307	$20.10	$71,473	$3.73	$103,834	$23.00

Tunnel No. 1—Sandstone of varying hardness and irregular fracture.

Tunnel No. 2—Cemented gravel and large boulders. Could not use augers or machine drills. Much overbreak.

Tunnel No. 3—Soft sandstone. Concrete run in from one end only.

Tunnel No. 4—Soft sandstone.

Tunnel No. 5—Soft shale with considerable gravel intermixed.

Tunnel No. 6—Soft shale. Lined in winter. Water hauled several miles under bad conditions.

Tunnel No. 7—Soft shale. Concrete material hauled 5.7 miles.

Tunnel No. 8—Soft shale with considerable overbreak. Concrete material hauled 6 miles and water 3 miles in winter over almost impassable roads.

The general construction program and designs for the work were prepared by Elbert M. Chandler, Chief Engineer of Washington State Reclamation Service, who was formerly chief engineer of the irrigation district. We are indebted to Mr. Chandler for the information in this article.

Labor Saving Tools in Street Railway Work

Mr. R. H. Findley, superintendent of Track and Roadway, Omaha & Council Bluffs Streets Railway, in a paper presented at a recent meeting of the Iowa Electric Railway Association, has the following to say with regard to the labor saving tools:

Roadway maintenance men must take advantage today of all devices and tools possible for elimination of labor. Men desire to pick their jobs and if forced into the "heavies," such as shoveling rock, handling ties, coal, etc., they expect more wages or hunt another job.

A 5-ton single-truck crane to handle ties and rail from stock piles to the job is "worth its weight in gold." We have used one for years and have also employed it for handling and installing all special work, moving rollers, rail girders, concrete mixers, air compressors, stone crushers, hydraulic rail benders, etc., back and forth from the yard to the job. The present-day economies of such equipment show a tremendous saving of labor. We are now using such a crane for removing the remains of some of the old cable railway, consisting of concrete slabs with cast-iron yokes, laid under the tracks and their miscellaneous underground structures, preparatory to grading a downtown hill in the city of Omaha. By being properly equipped for such work, we will cover the cost of removing this concrete and iron, out of the salvage.

An electric shovel for making excavations will lower the cost of loading wagons or dump cars to about one-fifth that of hand shoveling and will replace at least 20 men where its use is practicable. Such equipment is indispensable if a company wishes to accomplish anything.

Pneumatic tie-tamping outfits are very efficient for those using plain ballasted construction and produce a much better tamped track at less expense than hand tamping.

Derricks equipped with clam shells for handling rock and sand, and locomotive cranes where the volume of work warrants their use, are indispensable. There were times during the war when by the use of our 15-ton electric locomotive crane we saved as much as $100 a day on demurrage alone in handling steam coal. Crushed stone is unloaded from gondola cars for one-fifth of the cost of hand shoveling, and with fixed charges included, our cost today is less than if such material was unloaded by hand.

A stone crusher of portable size earns more for us than its original cost each year in reclaiming crushed rock and ballast from old materials formerly hauled and wasted at the dump. A crusher is particularly desirable in cities located some distance from quarries.

Dump cars, electric track drills, portable saws, hydraulic rail benders by which girder rail may be bent for curves, small jib cranes mounted on flat cars and modern concrete mixer machinery should all be mentioned as labor savers, invaluable to any railway.

Electric Dragline Averages 1,090 Cu. Yd. in Eight-hour Shift.—An electric dragline working on lateral construction for the North Platte Project of the U. S. Reclamation Service moved 58,800 cu. yd. of material during the month of October. Of the total 3,775 cu. yd. was Class 2 excavation. The actual yardage is probably 7 per cent in excess of these computed quantities. The record of the machine for the month was as follows:

Number of 8-hour shifts	54
Miles of lateral excavated	1.80
Average yards per shift	1,090
Average kilowatt-hours per cu. yd.	0.36

Rock Temperature in Deep Mines.—At the Witwatersrand mines in South Africa the temperature of the rocks increases at the rate of 4° for every 1,000 ft. in depth. At 4,500 ft. the temperature is 84°.

Present Status of Federal Railway Valuation Work

A committee report submitted at the recent annual convention of the National Association of State Railway and Utilities Commissioners contains a statement by C. A. Prouty, Director Bureau of Valuation, outlining the progress of the railway valuation work of his commission. According to the statement field work in the Southern district and road and track work in the Western district have been completed. The other branch work will run along for some months still. Road and track work in the Pacific district was completed in October and the structural work soon after. The mechanical work may run along for eight or nine months longer. In the Central district, road and track work will not be completed before Jan. 1, and perhaps not for two or three weeks in January. Branch work in that district is about three months behind the road and track work. In the Eastern district, owing to the fact that there will be no winter work, about half the road and track parties will be disbanded with the coming cold weather, and this will mean that the road and track work with a limited number of parties will extend over into next summer. The branch work is fully up to the road and track work in that district.

Director Prouty predicted that the field work will be completed by Jan. 1, 1920, and stated that he believes it will take about two years after the completion of the field work to prepare an engineering report upon all the principal railroads of the country. In other words, such reports should be ready for submission to his office and to the commission by Dec. 31, 1921. To put it another way, engineering reports had been completed on Dec. 31, 1918, on about 25,000 miles of road, and Mr. Prouty expected to receive reports during the current year on about 50,000 miles of additional road. For the next year the engineers ought to give the reports upon 75,000 miles and in the following year upon the balance. This depends, of course, on the ability of the bureau to find competent compilers and computers.

The field progress of the land section is not quite up with the engineering section, but the time needed in the office between the completion of the field work and the preparation of a report is much less in the land section than with the engineers. It is Mr. Prouty's expectation that land reports will be filed as promptly as engineering reports unless they are unduly held up by failure upon the part of the carriers to make their returns under Orders 7 and 16. Neither land nor accounting reports can be completed until some little time after returns to these orders have been filed by the carriers. The present indication is that most of the carriers will be on time.

Mr. Prouty stated that he had felt for some time that the greatest difficulty would be experienced in the accounting section. The result of this war has been to enormously increase the demand for good accountants. The bureau can find men who are competent to compile the information, but it is extremely difficult to secure accountants who can put that information together into the form of a narrative report. The field accounting work is in good shape and it is hoped to be able to work it up into reports as soon as engineering and land reports are ready. This also depends upon the promptness of the carriers in complying with Orders 7 and 16.

Mr. Prouty concluded his statement as follows:

"It is, therefore, my hope that by Dec. 31, 1921, we shall have ready for the commission, reports upon all principal carriers from the three sections and, if so, the commission will be in position to at once fix a tentative valuation upon all these properties. It is my belief that the tentative valuation so fixed would be found to be substantially correct, although it might in some slight degree be modified upon hearing of the objections of the carriers.

"You will see, therefore, that the work of the bureau of valuation so far as the initial valuation of these properties is concerned, is drawing to a conclusion. The task of keeping good that valuation is receiving careful attention and will from this time on assume greater proportions."

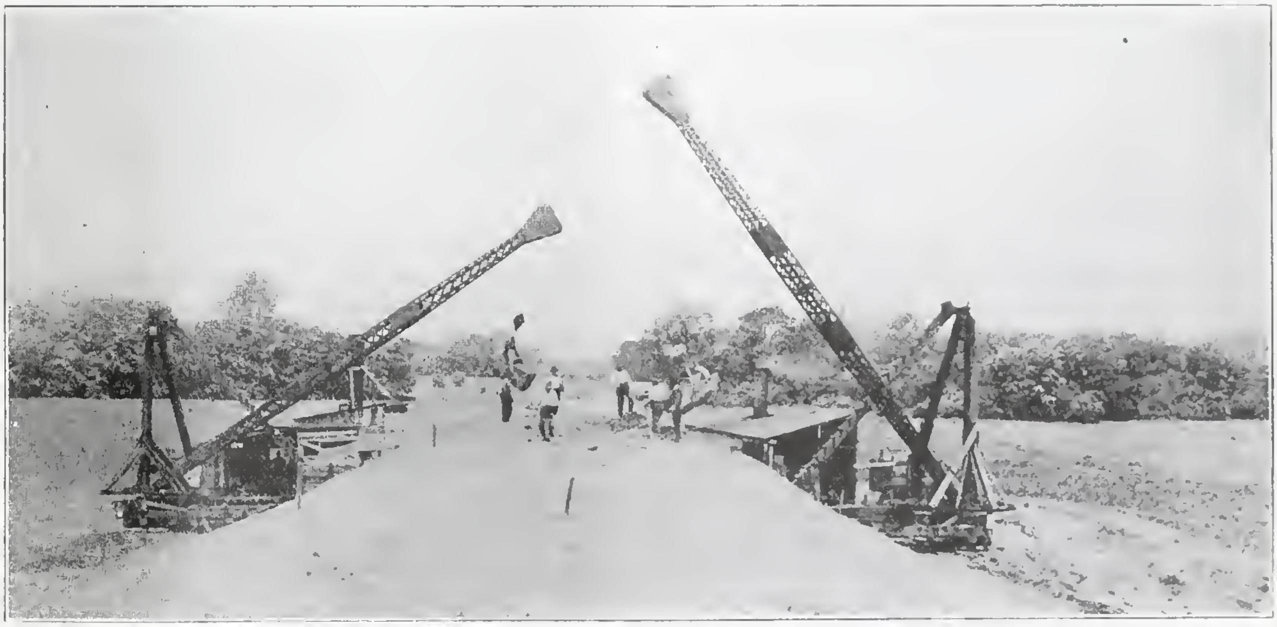
Bonus System for Sand and Gravel Production.—A bonus system based on production has greatly increased the output of the Beloit (Wis.) Sand & Gravel Co. As a bonus the superintendent receives 20 ct. and each laborer 5 ct. for every carload of material produced.

Railway Grading with Stiffleg Derrick Draglines

Two ordinary stiff-leg derricks equipped with drag line buckets were employed by the Miami Conservancy District for grading 1½ miles of the line of the Ohio Electric Ry. across the flats of the Mad River Valley, north of Osborn, O. The top soil is loam 1 to 3 ft. deep with gravel below. Water occurs 3 to 4 ft. below the surface. The fill varied from 5 ft. to 19 ft. The use of a plow with wheel scrapers or of an elevating grader with dump wagons would have required a right of 300 to 400 ft. wide, on account of the shallow cut necessary. The use of a dragline, permitting underwater excavation, reduced this width to 200 ft. The total excavation was 65,000 cu. yd. It may be pointed out that it is on such jobs of comparatively small size, where investment in large equipment would be unprofitable, that the adoption has its value.

The following particulars are taken from the Miami Conservancy Bulletin:

The district had two stiff-leg derricks available which had been in use at Osborn, both as derricks and as clam shells with 1-yd. buckets. It was proposed to take these two derricks; equip them with 1½-yd. dragline buckets, and work them as a team side by side, one to a borrow pit, on each side of the embankment to be built.


Stiffleg Derrick Draglines Building Electric Railway Embankment Across Flats of Mad River Valley, Ohio.

The two derricks were much alike and the description of No. 1 will be sufficient for both. The machine was mounted on a 30 ft. x 30 ft. base of 12 in. x 12 in. timbers, moving on 8-in. rollers. The mast was of white oak 14 in. x 16 in. by 24 ft. The boom was of yellow pine, 12 in. x 14 in. x 62 ft., equipped with hog rods. The bull wheel was 12 ft. in diameter. The hoist engines were double, 9 in. x 10 in., equipped with 3 drums 16 in. x 30 in. Ropes as follows: ⅝ in. boom-fall, ⅝ in. load cable, ½ in. hoist cable. Swing engines were double, 4½ in. x 5 in., with drum 26 in. x 12 in. The boiler was 48 in. x 8 ft. 6 in., vertical, carrying 100 lb. pressure. This machine was bought by the district in fair second-hand condition for $4,300. No. 2 was slightly smaller and cost $4,000.

Either of these machines could have been transformed into a dragline by substituting a dragline bucket for the clam shell, running the load cable from the breast sheave to the bucket through a mortise cut in the boom, the latter being strengthened on each side opposite the mortise by a 4 in. x 12 in. oak timber 10 or 12 ft. long, bolted through. The district, however, had on hand the stiff-legs from a steel derrick which had been re-equipped, and it was thought better to rebuild these stiff-legs into booms for the dragline derricks, with the hope that it would enable the use of a larger bucket (of 1½-yd. size), thus expediting the work. This was accordingly done. These booms were 20 in. x 20 in. at the center section, 62 ft. long, built of four angle irons 3 in. x 3 in. x ⅜ in., with lattices 5/16 in. x 2½ in. spaced 30 in., and with end plates at the top 4 ft. x 6 ft. x ½ in., carrying two 16-in. sheaves above and three of the same size below. These booms proved entirely satisfactory, although the buckets had to be reduced from 1½ to 1 cu. yd. in size.

The derricks ran on timber ways built up about 18 in. from the ground. This arrangement fitted well with the work of clearing out stumps, several acres of which had to be handled. The trees were sawed off close enough to the ground to permit the draglines to run over them, thus bringing them into the borrow pit, whence they were pulled by the dragline buckets acting as "tooth extractors."

It was the extracting of these stumps which threw the greatest strain on the transformed mechanism and led to the chief troubles in the way of breakages. All the cables had to be made larger, the final sizes adopted being ¾ in. for drag and swing cables and ⅝ in. for boom fall and hoist cables. Experience indicates that for drag cable 1 in. should be used on these size machines. The necessity of adopting ample sizes for cables is emphasized by the fact that the total cable bill on the 65,000-yd. job was $1,405.

Other chief difficulties encountered were due to wear of the sheaves, and breakage of the goose necks connecting the stifflegs to the top of the mast. Too heavy strain of dragline work also led to rather excessive wear on the pins of the breast sheaves and bottom sheaves. The breast sheaves were 14 in. diameter with 2 in. pins; 16 in. diameter with 3 in. pins are recommended. The bottom sheaves were 16 in. with 2½ in. pins; 24 in. diameter with 3 in. pins are recommended. Here again the bill for sheaves on the job—$628—tells the story of the necessity of attention to these details. The goose necks were 2 in. x 10 in. plates bolted to the under sides of the stiff-leg timbers. They were reinforced by 1 in. x 10 in. plates bolted through on the top side of the timber, the bolts being 1¼ in. x 18 in. and six in number. With this change no trouble has been since experienced.

The greatest single delays were due to stoppages necessary to reflue the boilers on both derricks and to repair a badly worn drum pinion. These delays, due to other causes than those characteristic of the dragline job, are not strictly chargeable to this work.

The force of men required for the draglines proper were:

1 foreman.
2 dragline runners.
2 firemen.
1 pumpman.
8 laborers.

In addition to the above 2 to 3 men were kept on the embankment dressing the crown and slopes. The working day was 10 hours, of which a 2-hour loss, due to stoppages for repairs, oiling, moving ahead, etc., was considered normal. The job took about four months. The figures follow.

Original cost of derricks: No. 1, $4,300; No. 2, $4,000. Operating expenses as follows:

Shop repairs	$ 2,407.33
Labor	13,331.14
Materials (cable, coal, etc.)	3,062.80
Field accounting	220.96
Hauling draglines, Osborn to Dayton	216.96
Dayton garage	8.42
Total	$19,247.61

The total material moved was 65,000 cu. yd.. giving an operating cost per cubic yard of 29.6 ct. Deducting time lost for retubing boilers and cost of repair of same, these items not being fairly chargeable to the job, reduces the cost to 26.7 ct. This represents a contractor's cost, with materials, repairs and labor obtained in the open market, and no overhead except for field accounting. As an interesting comparison, it may be noted that the contract's bid for the job before the district undertook it by force account, was 35 ct.

It was a great advantage for the use of these draglines here that much of the material could be taken from under water, thus lowering right-of-way cost. An additional advantage of this was that all of the material was put in the bank soaking wet, making an unusually solid structure. The banks were staked for 5 per cent shrinkage only, on this account. The finished structure shows not more than 2½ to 3 per cent.

The idea of the transformation came from Wm. McIntosh, Master Mechanic for the district, but the successful carrying out of the scheme was due in no small degree also to the efficient co-operation of Leslie Wiley, Superintendent, and John Rosite, Foreman on the work.

Exterminating Ground Squirrels by "Gassing"

Mr. Clifford A. Elliott, Cost Engineer, Maintenance-of-way Department, Pacific Elec. Ry., Los Angeles, Calif., writing in the Electric Railway Journal, describes what appears to be the very latest war-time method of fighting ground squirrels. The damage which these rodents do in burrowing into the banks of cuts along the right of way and into the roadbed itself has been a constant source of trouble in maintenance work, the most damage being done in the rainy season, when storm water enters the holes and loosens the cuts, causing landslides. Bridge embankments suffer seriously from the same cause.

In the spring months the squirrels leave the right of way and go into adjoining fields, where growing crops are destroyed.

The damage to the crops on abutting farms each year is very great, and the farmers complain continually of the pests which inhabit the company's right-of-way. Each year the company co-operates with the farmers in carrying on a campaign to eliminate them, and additional aid is given by the State Horticultural Commission of California.

Attempts have been made to exterminate the squirrels by putting out poison-soaked hulled barley. This has done some good, but during the spring season the plan is of no avail, as the ripe, juicy roots of growing grain in the fields are more appetizing, and the rodents refuse to eat the barley that has been scattered for them near their burrows.

The company has recently found in the market an automatic distillate vapor machine for gassing the squirrels in true war-time fashion, and the use of this device has gained excellent results. The squirrels are gassed in their burrows, as are also other small animals, such as rabbits, badgers, snakes, owls, etc., which unfortunately inhabit the same holes as the squirrels.

Ordinary engine distillate is used in the machine, from which is produced a white vapor which is forced into the burrows and effectually disposes of the rodents. Adjacent holes are watched and as soon as any vapor appears from them, the operator's assistant tamps them shut for at least a foot deep. The burrows are filled with vapor and the hole at which the discharge pipe has been operating is then tightly closed by tamping. The best time to gas is said to be just after a rain, when the holes have been opened up by the water. One foreman and four men with two gas machines average 80 main burrows per 10-hour day, with a consumption of 3 gal. of distillate.

Instructions to Construction Foremen for Prevention of Accidents

While the following instructions were prepared primarily for conditions in the steel erection field, they nevertheless contain suggestions that are applicable to many other lines of construction. They are reprinted from a booklet prepared by the Erection Department of the McClintic-Marshall Construction Co.

See that Your Equipment is Sufficiently Strong.—It is your duty to see that the equipment and tools you use for each part of the work are sufficiently strong to handle the same safely.

You should see that the derricks you use are amply strong for the loads to be lifted. The goose neck and gudgeon pin are the critical points of a derrick If you have any doubt about the strength of the goose neck, provide heavy wire guys from gudgeon pin to sill at base of stiff-legs. Don't lift a 10-ton load on a 5-ton derrick. The same thing applies to gin poles and travelers. Don't overload your equipment and don't run any chances where life is endangered. Be careful not to lift any but a light load on a derrick if the length of the boom exceeds 70 times the least width or thickness of the boom: that is, if your boom is 12 in. x 14 in. the least width is 12 in., you should not lift a heavy load on this boom if it is more than 70 ft. in length.

See that travelers are well and carefully framed and erected, well braced and capable of withstanding the greatest wind, and shocks from heaviest loads that are to be lifted.

See that the hooks, shackles and buckets on your blocks are amply strong, and don't allow a gate block to be used without it being closed and hooked. Also see that your cables and chains, as well as the rings and hooks in the same, are amply strong for the loads to be lifted.

Do not use old or worn line when there is any danger to men or material by so doing. Cut out the use of manila line whenever possible. When you are obliged to use it be sure it is amply strong. Use steel cable whenever possible, as it is safer, will last longer and is cheaper in the long run. Be sure that the guy cables for gin poles, derricks, etc., are of sufficient size to withstand the tension to come upon them. Also that the cables are securely fastened by means of a sufficient number of good, strong clamps well fastened, and also that dead men or other anchorage are ample, and watch them when lifting heavy loads to see that guys do not cut dead men in two. Keep gin pole guys as near at right angles to each other as possible, when only four are used.

You should be careful to see that the gas pipe or wooden scaffold you use is of proper size and strength for the span and loads. If there is any question about the strength, test the same by applying several times the load that will come upon it. See that plank you use for scaffolding, etc., is the right kind of wood, preferably white or yellow pine, free from knots and shakes and plenty strong, watching to see that it is thick enough for the span on which it is used.

Do not put heavy loads on light push cars. The frame is not only liable to crush but the shafts, boxes or wheels may bend or break, upsetting the load and injuring the men.

See that Your Equipment is in Order.—In setting up your derricks see that they are plumb, properly guyed and that the splices are brought into contact and bolted with tight-fitting bolts. See that the goose necks fit gudgeon pin closely and are not cracked or bent and that the top of stiff-leg is tied down from the goose neck to the sill to prevent lifting tendency. If the timbers in the mast, boom, stiff-leg or sills are rotten, knotty or wind shaken, do not use them. See that your gudgeon pin and pintle casting are well fastened to the mast, and if the mast is of wood that the wood is not rotten or worn at these points.

You should see that all leads are as straight and direct as possible, as failure to provide good leads reduces the efficiency of your power and equipment, as well as producing heavy wear on the lines and is a frequent cause of accidents. Particular care should be exercised in securing good leads for wire cable on account of liability of breaking the individual wire strands by sharp bends or indirect leads. A broken individual wire is liable to lie across and cut the other wires of the cable.

When you use a wooden traveler see that the timbers are all in good condition and that it is erected plumb and square and the joints properly and securely bolted. More accidents occur from the use of wooden derricks and wooden travelers than from any other cause, and for this reason extreme care should be exercised to see that they are in good condition before using them. When a traveler is used, see that it is properly erected and thoroughly bolted and all sway and bracing rods tightened.

Do not use an iron gin pole if the sections are bent or dented seriously, or the splices do not clamp the pole tightly and securely. Do not use a wooden gin pole unless the timber is in good condition, well spliced with good long splices securely bolted.

See that your hoisting engine is in good order; that the shafts are not bent, the dogs, clutches and brakes, including the friction, are in good condition and working order. The lever controlling winch heads should be straight and when thrown in should engage the ratchet fully. See that winch head cannot slip off shaft. See that the boilers are cleaned frequently and kept in good condition.

You should be particular to see that gas pipe scaffolding is not rusted on the inside and that it is fastened so that it cannot roll or turn. Do not use any plank or timber for scaffolding that is knotty, rotten or weather cracked, and allow no man to work on scaffold plank laid loose on the supports. The plank should be fixed so that they cannot move or slide endwise, by using drop bolts.

All cables should be in good condition and kept oiled or greased so that they will not rust; if they are not in good condition, do not use them. All guy cables should be securely fastened by means of a sufficient number of good clamps.

See that your chains and the rings and hooks in the same are not worn, cracked or bent out of shape and that they are annealed at least once every three months in an annealing furnace, if you are near one, or otherwise anneal them yourself by laying them down in a straight line and building a good sized wood fire over them heating slowly to a cherry red, then cover over thoroughly with ashes and heated dry dirt leaving them to cool slowly in the ashes and dirt. In laying the chains down in a straight line do not lay one chain on top of another. Be particular to see that the covering is ample so that air or moisture cannot cool the chains quickly or partially. This annealing should be done on Saturday and chains not disturbed until Monday. Chains used frequently every day should be annealed once a month.

See that your blocks are in good order and that the beckets, shackles and hooks are not bent, cracked or out of shape and that face of blocks are in good condition, also that the sheaves are not cracked or the flanges broken.

See that all button sets are fastened to the air hammers.

See that Your Equipment and Tools Are Properly Used.—In using a locomotive crane be sure that your track is properly ballasted and level and the rails well spiked down. Do not lift a load sideways when the locomotive crane is standing on a curve, without using extra care. Use your outriggers and rail clamps when lifting a heavy load.

The loads that a locomotive crane is capable of handling safely for each radius are plainly marked on the crane; don't attempt to lift heavier loads with the crane.

See that the booms of locomotive cranes, derrick cars or derricks, are in first class condition. If the boom (or flanges of the boom) has been injured or bent, don't use it, but replace the broken or bent part with new material. Don't attempt to straighten it, as the material in all probability has been injured, and will break or collapse sooner or later.

A locomotive crane is a useful, but dangerous piece of equipment, for this reason the greatest possible care should be exercised in handling the same. Don't allow any man on the car or crane cab, except the craneman, and keep workmen from under the boom. Don't attempt to shift track with your crane standing on the same track, and don't attempt to lift a maximum load with the boom horizontal.

You must be especially careful in swinging boom sidewise or lifting loads sidewise with a derrick car as your car will upset unless you use outriggers or guys. Don't run chances but lift the load straight ahead wherever possible. See that the boom on the derrick car is tightly guyed at all times with wire rope running from end of boom to sides of car. Never use manila line for this purpose, as it will stretch and your boom will get away from you, upsetting the car. Use additional guys to end of boom when setting heavy loads.

In carrying loads with a locomotive crane or derrick car on a curve, be sure that the track is level and the outer rail not elevated as is customary with railroad track.

Be very careful in using a wooden boom extension or outriggers, that you do not lift too heavy loads. The increased length of the boom and the weight of extension reduce the lifting capacity considerably.

Whenever possible, avoid the attachment of guy lines to railroad tracks, as numerous accidents have occurred by car running into the guys.

Hook on to sheets or bundles of small material so that they cannot slip out.

Don't allow men to carry glazed window sash on their shoulders when wind is blowing.

See that gate blocks are securely fastened and that men do not stand in the "bite" of a line.

Do not use a light gate block when lifting heavy loads.

Lines should be run around two winch heads when making a heavy lift.

When you use a derrick keep the boom elevated above a horizontal line as far as possible, as generally the worst stress comes on the boom and mast as well as stiff-legs or guy lines when boom is in a horizontal position. A maximum load for the derrick should never be lifted with the boom in a horizontal position.

When you use a pin pole see that the splices are well bolted and the pole is properly guyed. Do not lean the pole too much when lifting a load or moving the pole and see that the foot of the pole cannot move or slip except when you desire to move it.

A number of accidents have occurred through the improper loading of push cars. See that the load is properly placed so that it cannot roll or tumble over, especially going around a curve. Do not allow your men to push on the side of the car with a top-heavy load. They should push or pull from the ends of the piece.

When you lift a beam or girder use scissor dogs or cast steel girder hooks wherever possible, and if you are obliged to use either ordinary dogs or chains see that wooden blocks are used between the chain or dog and the flange to prevent the girder from slipping.

Avoid the use of chains except for lifting light loads. Where you have heavy loads to lift use cable slings, being careful to avoid sharp bends by using rounded wooden blocks between cable and load.

Don't put too many parts of lashing into a hook as by doing so you are liable to open up the hook.

See that exposed parts of dangerous machinery are properly covered.

Be Orderly—Careful.—See that your work is carried on in an orderly, careful manner.

See that material is unloaded and piled in an orderly, careful way so that it cannot fall, turn or be blown over.

Unless necessary, do not hoist any material to a structure until you are ready to put it into position and properly fasten it. In cases where you do hoist material to the structure before putting it in its final position, see that it is piled in an orderly way so that it can not turn or roll over when a man steps on it.

Don't let tools or equipment such as bolts, nuts, drift pins, blocks, dolly bars, etc., lie around so that they can be knocked off the work or so that any one can fall over them.

Keep everything orderly and in ship-shape and allow nothing to lie around.

Be Vigilant.—You must use vigilance and be on the job practically all the time to see that your men are carrying out your instructions; that tools and equipment and men are in fit condition for the work and that they are handling the work carefully and intelligently.

Be careful and insist on the men under you being careful, and do not allow any one who is reckless and careless to work for you.

Whenever any question as to the safety of equipment or tools or the work which you are erecting is brought to your attention by any of the men under you or others, investigate the same and satisfy yourself of the safety of the same before proceeding further. If you are satisfied the work, equipment or tools are not safe, put them in a safe condition immediately.

See that Proper Instruction Is Given Employes.—Call attention of men to any dangerous conditions on the job so that they can be on the lookout.

Your faithful attention to this matter is to the interest of employe and employer alike.

Unfit Condition.—You must see that every employe under you is in proper physical condition. They should be strong, temperate, clear-headed, with good eyesight, good hearing, and not lame or crippled.

Do not allow any man to go to work who has been drinking or drinks during working hours or who is sick or in unfit condition. A man's mind is not clear who is at all under the influence of liquor and thus endangers his own and fellow workmen's lives.

Don't employ ignorant persons.

Don't employ any one under 18 years of age and preferably no one under 21. Those employed between the ages of 18 and 21 should be strong, sober, healthy boys who desire to learn the business. You must secure a written permit from the parents of all boys under 21 years of age, authorizing you to employ them. Forms for this purpose will be sent you.

The character of this business is such that a workman should be strong and sound in body, temperate in habits, clear and alert in mind, to avoid accidents.

Use Judgment.—You must use judgment in assigning men to do certain work and see that they are capable and experienced in the work to be done.

Signal men should be capable, experienced bridgemen, and should stand in a position where they can be seen by the men at the hoisting engine and those connecting the work. Signals should be clearly understood. Use none but good, careful, experienced locomotive cranemen, derrick car men, and men on winch heads.

Don't resort to expediency by allowing an inexperienced man to do the work where experience counts. Educate the men up to their work. Don't throw too much on inexperienced men all at once.

You should see that the pusher and men use proper tools to do the work and handle same properly.

Don't allow your men to work on crane runway when cranes are in motion.

Don't allow men to work on scaffold that you would not work on yourself.

Where there are heavy pieces to be lifted see if the weight is marked on the piece; if not, get the weight from the invoice and mark it on, calling pusher's attention to it.

Do Not Allow Men to Work in Perilous Places.—You must see that your men are not exposed to extremely hazardous conditions and that they are not allowed to work in extremely dangerous places.

Do not allow your men to work under loads and in places where there is imminent danger.

Be careful not to allow men to work on the roofs of buildings when there is frost, ice or snow on the same, without taking extra precautions. The same applies to other steel structures.

See that Workmen Obey Following Rules.—Don't Be Reckless: More accidents occur through recklessness than any other cause. Don't walk on rods. Don't ride a load. Don't ride on a locomotive crane.

Don't Be Careless: Look where you step and be sure that on what you step is safe and secure. Don't step on ends of loose plank. Don't start to slide down a line unless you are sure the ends are fastened.

Be Orderly: Do whatever you do in an orderly, careful manner. Pile material so that it cannot roll, fall, tumble, or be blown over. Don't let tools or equipment such as bolts, nuts, drift pins, blocks, dolly bars, etc., lie around so that they can be knocked off the work or so that any one can fall over them.

Unfit Condition. Don't go to work if you have been drinking or do not feel well. If you are lame or have any defect in hearing or eyesight you should not work at this business as by so doing you endanger your own and fellow workmen's lives. If you are inexperienced in, or unsuited for the work to be done, don't undertake it.

Be Vigilant: Watch what you are doing. Don't stand or work under a load. Don't go in the "bite" of a line nor stand in front of a snatch block. Don't work on or about a crane runway when the crane is in use unless there is a stop between you and the crane.

Don't Use Unfit Tools: Be sure the tools and equipment you use are in good working order. If they are not, don't use them.

Don't work with men who don't observe these rules.

Hints on Hauling Heavy Loads

Two principles that are of great importance in hauling heavy loads over roads by teams are: First, the motive power should be applied as close to the load as possible, and second, the vehicle should have tires of sufficient width to support the load without cutting deeply into the road. The application of these principles are illustrated and described in an article by H. L. Goodwin in the Mining and Scientific Press, to which we are indebted for the matter that follows.

Where horses are used, the bad effect of having them strung out at some distance from the load lies mainly in the necessity of taking up the slack in the rigging. This is not so important a factor where trained teams, used to working together day by day, are used, but with the scrub teams often of necessity employed in hauling heavy mining machinery it is of considerable moment. The difficulty lies mainly in getting the horses to pull steadily as a unit. When the rigging is so made up that the total tractive effort is applied to the load at several places, say, two or three, this trouble is largely eliminated.

In one instance ten horses and a motor-truck were used in hauling a heavy grinding-mill. Two horses were left on the pole, and the other eight were placed four abreast in the lead. Each of the four-horse units was attached directly to the load by chains from the middle of a long spreader. It was also necessary to attach the ends of the spreaders to the load, so that if the off horses should pull more than the near, for instance, no harm would result. The motor-truck was used with a pushpole in the rear.

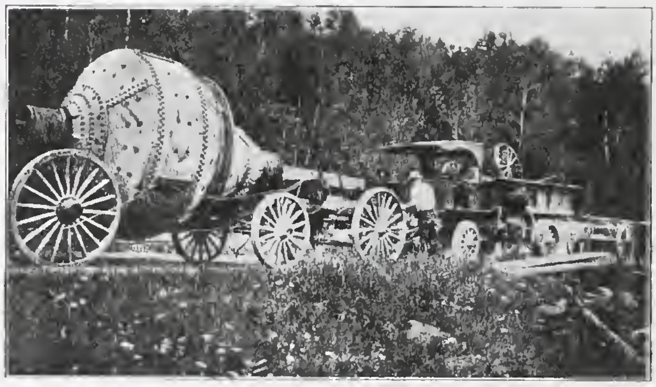


Fig. 1—Two Sets of 5-in. Tired Wheels Gave Same Effect As Wider Tired Trucks.

In another case ten horses were used, six in front of the load, two abreast, and four in the rear, hitched to a push-pole. This is much preferable to having the ten horses strung out, two abreast, in front of the load.

The width of tires on the vehicle is evidently of minor importance on paved thoroughfares, but on earth roads a great burden is added if the wheels sink into the road. Tires should be at least 6 in. wide for loads of over 5 tons. Fig. 1 shows how two sets of 5-in. tired wheels were used with essentially the same effect as though wider-tired trucks had been available. The two pairs of wheels used at each end of the load were placed close together, and so connected with chains that they would "follow" correctly in going around curves.

In one case when it became necessary to resort to tackle in order to get a heavy crusher up a steep grade, two horses were left on the pole to steer the load, and a motor truck was trigged in position to serve as an anchor for one end of the tackle. The advantage of having an anchor so readily movable is evident.

37-Year-Old Crusher Still in Service.—A No. 5-B Gates crusher with openings 10 x 30 in., sold in 1882, is still in operation at the Richmond, Wis., quarry of the Mayville White Lime Works. This quarry, after 8 years of idleness, was placed in service last spring. The old crusher was rebabbitted at that time and since then has had no repairs. H. A. Martin, vice-president of the Mayville White Lime Works writes to the Allis-Chalmers Manufacturing Co., that judging from the present condition of the crusher "it should be crushing stone for a good many years yet."

Leakage Resistance of Street Railway Road Beds

According to Mr. E. R. Shepard, Electrical Engineer of the Bureau of Standards, it seems that street railway engineers have given little thought to the question of insulating roadbeds or constructing them in such a manner as to offer high resistance to leakage currents. He has collaborated with the U. S. Forest Products Laboratory at Madison, Wis., in a paper on this subject giving the results of numerous experiments conducted and the conclusions drawn therefrom. What follows is an abstract of this paper, as given in "Electric Traction":

The leakage path traversed by stray currents from electric railways consists of several elements and varies greatly with the different types of roadbed construction. In the case of open track, the current leaves the rails, entering the ties through the spikes and the base of the rails, and then passes into the ballast and finally into the adjacent earth from which, part of it finds its way to metallic structures, and eventually to the negative pole of the generator. In paved streets an additional leakage path is offered through direct contact of the rails with the earth, pavement, or other material in which they are imbedded.

In this paper the part of the circuit in which we are concerned is termed "the roadbed" and consists of the pavement, ties, and ballast. By far the greatest part of the total resistance of the leakage path is to be found in the roadbed, particularly in open construction, where the wood ties almost act as insulators between the rails and the earth. In the case of the earth ballast or where the rails are laid on a natural gravel ballast, the extent of the roadbed is, of course, indefinite. In determining the resistance of any types of roadbed, an attempt was made to measure the resistance of the earth between the roadbed and the remote ground, but as this is only a very small fraction of the total resistance where ordinary types of construction are involved, it is here included in the roadbed resistance.

Owing to the difficulties involved in making resistance measurements on city tracks and the limited number of types available for such tests, it was decided to build short sections of a number of different types of roadbeds on which frequent measurements could be made. It was realized that such roadbeds might exhibit quite different characteristics from similar types subjected to the action of traffic, to the surface drainage from city streets, and to the presence of salt which is frequently used to prevent freezing. Such roadbeds would, however, permit of a careful study of the effect of moisture and temperature and would also enable comparative measurements to be made which could be checked by similar data obtained from city tracks under operation.

Fourteen types of experimental roadbeds were built on the Bureau grounds early in 1915. In selecting these types of roadbeds an attempt was made to include those most commonly used in practice as well as to introduce certain modifications in the way of insulating materials which it was believed might prove of practical value in reducing stray currents.

Ties treated with several different kinds of preservatives were also used in order to determine the effect of such treatments on the resistance of the wood and the leaching effect of the weather on the different preservatives.

Conclusions Regarding Leakage Resistance of Roadbeds.—The results of resistance measurements on the various types of roadbeds led to the following conclusions.

1. Roadbeds constructed with solid-concrete ballast and vitrified brick, or other nonporous pavements, have a low leakage resistance to earth, which is affected only moderately by seasonal and weather changes. There is little difference between wood and steel ties in their effects on the resistance of roadbeds of this kind. Insulating layers of bituminous materials are not of practical value in reducing leakage currents from such roadbeds. The resistance of 1,000 ft. of single roadbed of this type is from 0.2 to 0.5 ohm under ordinary conditions, but may be double or treble these values when the ballast is frozen to a depth of 1 ft. or more. For double road bed of this type the resistance is approximately 70 per cent of that for single roadbed, or the leakage from double track would be about 40 to 50 per cent greater than from single track.

2. Roadbeds constructed with a foundation of clean, crushed stone under a concrete paving base have a much higher resistance than roadbeds with a solid-concrete ballast. In the case of the experimental roadbeds the ratio was found to be about 3 to 1.

3. Roadbeds with a full crushed-stone ballast and a Tarvia finish have a very high leakage resistance, which is of the order of 2 to 5 ohms from 1,000 ft. of single track. The leakage from a double roadbed of this type and other high resistance types is from 80 to 100 per cent greater than from single roadbeds.

4. The resistance of earth roadbeds in which the ties are embedded, and therefore kept in a moist condition, is much lower than that of open-construction roadbeds, being from 1 to 1:5 ohms for 1,000 ft. of single track under normal conditions and considerably more when the ground is frozen.

5. The resistance of roadbeds of open construction is subject to wide variations, depending on the condition of the ties and ballast. In very dry weather with good ballast the resistance will be 10 to 15 ohms, and even more for 1,000 ft. of single track, but when wet will drop to from 3 to 5 ohms. Cinders, gravel, and particularly crushed stone, when used as ballast in opentrack construction, produce very high resistance roadbeds. Earth has a tendency to keep the ties moist and therefore increases the leakage.

6. Open-construction track is often considered as being insulated from the earth, but this is not strictly true, even though the leakage may not be in harmful amounts when compared with other types of construction. Assuming a potential difference between a track and the earth of 5 volts and a leakage resistance of 10 ohms per 1,000 ft. of single roadbed the total leakage per mile of track would be 2.64 amperes. This small leakage current would not ordinarily be harmful to underground structures in the vicinity of the track.

7. Zinc chloride and other chemical salts used as preservatives render ties highly conducting and greatly increase leakage currents from tracks. Unless combined with some other material such as creosote, these salts gradually leach out, particularly in damp climates, and eventually their influence on the resistance of roadbeds disappears. Creosote has very little effect upon the resistance of wood ties, but a treating material consisting of 75 per cent gas oil and 25 per cent creosote appears to increase their resistance materially. No direct comparison, however, was made between these two treatments. Open-track construction on which ties treated in this manner were employed had a leakage resistance about twice as great as similar roadbeds with untreated ties and about four times as great as roadbeds with chemically treated ties.

Suggestions Regarding Roadbed Construction.—Electric railway companies can do much toward reducing leakage currents from their tracks by observing the following suggestions regarding roadbed construction:

1. Solid-concrete ballast should be abandoned, and clean crushed stone should be used as a foundation under ties. This type of construction is approved by the American Electric Railway Association, as it gives greater resiliency to the track and is cheaper than the full concrete ballast.

2. Where crushed stone or gravel is used it should be kept clean by proper coverings or pavements. If earth, sand, or street dirt is permitted to filter into ballast of this character, its function as an insulating material is greatly impaired.

3. Salt, which is often used to prevent frogs and switches from freezing, will greatly reduce the resistance of roadbeds and should be avoided if possible.

4. In open construction rails should be kept out of contact with the earth. The roadbed should be well drained to prevent fine material from washing into the ballast and to keep the ties as dry as possible. Vegetation should be kept down, as this tends to make the roadbed moist and to fill the ballast with foreign material.

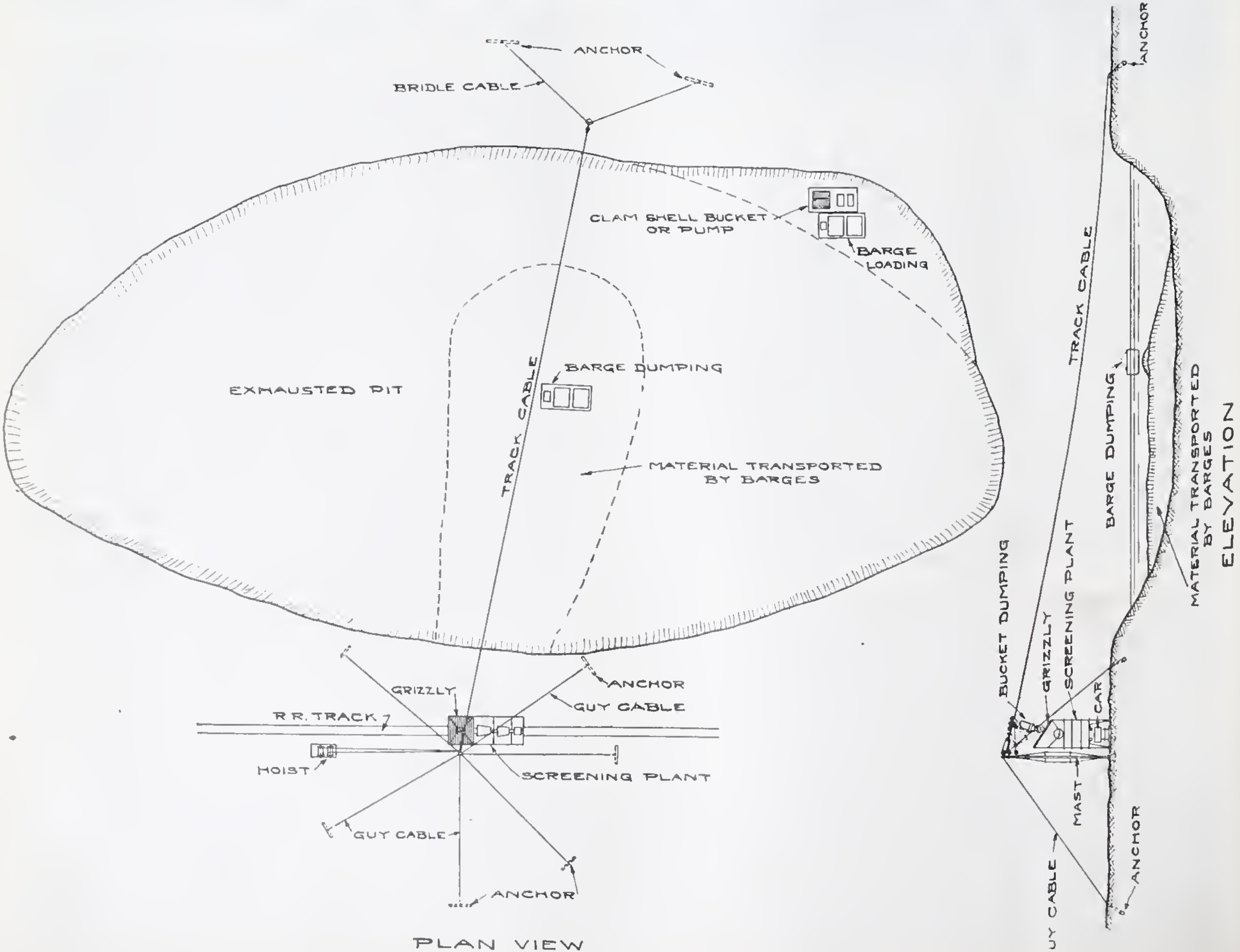
5. Zinc chloride and similar chemical preservatives should be avoided where the escape of stray currents is objectionable or where block signals are used. A treating mixture of creosote and gas oil improve the insulating properties of wood ties.

Using Old Pit for Winter Storage of Gravel

A novel scheme of under-water storage of gravel, which will permit a continuance of operations all winter in preparation for next year's business, is being successfully carried out by W. K. and Geo. V. Miller, owners of the Granite Sand & Gravel Co. at Indianapolis, Ind. At the same time they have found a new application for the dragline cableway excavator. The 2 cu. yd. Sauerman dragline bucket which they have operated on a 690-ft. span cableway for six years, and which has practically exhausted all the material within its reach, will henceforth be used on a shorter span, serving essentially as a conveyor only.

A barge equipped with a derrick carrying a 1¼ yd. clamshell bucket, and a bottom-dump barge of 60 cu. yd. capacity, propelled by a small gasoline engine, have been added to operate in conjunction with the dragline cableway excavator. The floating clamshell excavates along the banks of the pit and loads into the dump barge, which conveys the material to a point close to the screening plant and in the path of the cableway, the latter being lowered under water while the barge is discharging its load. The material is then picked up and conveyed to the screening plant by the cableway excavator, and as the distance is only 200 to 300 ft., the material

Pit of Granite Sand & Gravel Co.



Plan and Elevation Showing Underwater Storage Method.

is handled to the plant at the rate of about 2 cu. yd. a minute. Although the entire plant may be operated only occasionally during the winter, the excavating and storing of material will proceed without interruption. As the pit has a 40-ft. depth of water, ample space is afforded for storing the material where it is safe from freezing and where it can be reclaimed with a minimum of effort and expense to meet the rush demands of contractors next spring. Mr. W. K. Miller states that with this stored material to draw from and with the excavator bucket working on the shorter span cableway, the capacity of the plant will be increased 10 to 15 cars per day next year.

In addition, the new method eliminates the cost of stripping which would amount to about $2,500 per acre. An average overburden of 2 to 4 ft. is allowed to cave into the pit. If the material excavated by the clamshell is very dirty, it is run through a Stocker washer mounted on the same barge as the clamshell. This washer discharges into the hopper barge. If the material excavated is clean, as is the case most of the time, the clamshell discharges directly into the barge. One man operates the dump barge.

A final advantage of this scheme is that the two parts of the plant are independent and either can be operated without the other, as the business may demand.

Costs of Railway Ditching by Various Methods

An interesting comparison of costs at 1918 prices of cleaning railway ditches by different methods was given in a committee report at the recent annual meeting of the Roadmasters' and Maintenance of Way Association in Chicago. The data given are for single track lines with six trains during working hours; roadbed in soft clay; ditches 7 ft. from rails, 3 ft. wide and 2 ft. deep. The following is a summary of the output and costs by the different methods:

	Output per day. Cu. yd.	Cost per cu. yd
Ditcher of steam-shovel type, on cars....	224	$0.4130
Steam ditcher of drag-scraper type.....	252	.4034
Push cars and laborers..................	38½	.5862
Car barrows and laborers...........	13	.7670
Wheelbarrows and laborers.............	19	.7142
Casting or shoveling.....................	38½	.3525

The unit costs for the various methods follow:

	Per day.
Ditcher of steam shovel type on cars:	
Ditch labor	$18.90
Work train labor	23.86
Rental of equipment	31.00
Maintenance of equipment	1.45
Supplies	12.80
Total (224 cu. yd. at 41.3 ct.)	$92.51
Steam ditcher of drag scraper type:	
Ditch labor	$31.75
Work train labor	28.36
Rental of equipment	30.00
Maintenance of equipment	.93
Supplies	10.62
Total (252 cu. yd. at 40.3 ct.)	$101.66
Two push cars and hand labor:	
1 foreman at $83	$ 2.77
11 laborers at $2.25	19.80
Total (38½ cu. yd. at 58.6 ct.)	$22.57
Car barrows and hand labor:	
1 foreman	$ 2.77
4 laborers at $1.80	7.20
Total (13 cu. yd. at 76.7 ct.)	$ 9.97
Wheelbarrows and hand labor:	
1 foreman	$ 2.77
6 laborers at $1.80	10.80
Total (19 cu. yd. at 71.4 ct.)	$13.57
Casting or shoveling:	
1 foreman	$ 2.77
6 laborers at $1.80	10.80
Total (38½ cu. yd. at 35.2 ct.)	$13.57

Electrification of Italian Railways.—The Italian government proposes to electrify nearly 4,000 miles of state railways and many of the lines privately operated. The project will involve an expense of $154,400,000 and will require at least 10 years for its execution. Up to the present time about 265 miles of railway in Italy are electrically operated. The new work will be executed either directly by the state railway administration or by private firms under the supervision of the state, as may be decided by the ministry of transportation.

Safe Practice in Use of Wire Rope in Hoisting

In the course of its investigations of safety in mining, the Fuels and Mechanical Divisions of the Bureau of Mines collected much information bearing on the use of wire rope. This information has been compiled in a technical paper issued recently by the bureau. This paper, prepared by R. H. Kudlich and O. P. Hood, outlines approved practice and the important precautions to insure safety. While it aims simply to emphasize the essentials of good practice and to give reasons underlying such practice, it contains so much useful information that we are reprinting it.

Size of Rope.—Never exceed the working load of the rope as given in the manufacturers table. The rope must have a factor of safety to allow for wear, corrosion, and severe strains due to starting, etc.

The factor of safety is calculated by dividing the breaking strength of the rope by the sum of the weight to be hoisted plus the weight of rope in the shaft. The table below gives values for the factor of safety recommended by the Bureau of Mines:

HOISTING ROPE SAFETY FACTORS FOR VARIOUS DEPTHS OF SHAFTS.

Length of rope, ft.	Minimum factor of safety for new rope	Minimum factor of safety when rope must be discarded.
500 or less	8	6.4
500 to 1,000	7	5.8
1,000 to 2,000	6	5.0
2,000 to 3,000	5	4.3
3,000 and more	4	3.6

Material in the Rope.—The material of the rope should be adapted to the service in which it is to be used. Use soft steel rope in shallow shafts where there is strongly acid water and drums or sheaves are small. Use hard-drawn steel or plow-steel rope in deep shafts, on slopes, or on rope-haulage ways.

Rope made of the softer grades of steel is more flexible and less affected by corrosion, whereas rope made of steel of high tensile strength is not so heavy for a given strength and resists abrasion better.

Construction of Rope.—The construction of the rope should be adapted to the service in which the rope is to be used. Where flexibility is required, a rope of a large number of small wires may be used if it is not subject to excessive external wear, whereas a rope made of a smaller number of larger wires must be used where the rope is subjected to severe external wear.

The smaller the wires of which the strand is made the greater the strength and flexibility of the rope. In vertical shafts the rope generally used is made of six strands of 19 wires each, laid around a hemp core. In slopes and on haulageways where the rope is subjected to excessive wear by rubbing against the sides, floor, and roof, the rope generally used is composed of six strands of seven wires each, laid around a hemp core.

Lay of the Rope.—Lang-lay rope should be used except where the tendency of the rope to untwist is harmful and can not be resisted. In such places regular lay ropes, or special nonspinning ropes should be used. Lang-lay rope should be used especially where external wear is severe, if it can be prevented from untwisting.

In the most common form of rope the wires are laid into round strands. Such ropes are either regular lay or lang-lay; that is, the wires and the strands are laid in opposite directions or in the same direction. Regular lay rope does not tend to untwist when loaded, but only a small portion of each wire in a strand is subject to external wear against sheaves, drums, and to internal wear against the wires of the other strands. Lang-lay rope tends to untwist under load, but a considerable length of each wire comes in contact with the sheaves or drum or with the wires of another strand, and thus wear on the outside of the rope is distributed and "nicking" of the inside wires is greatly reduced.

Length of Rope.—New ropes must be long enough to permit cutting off the end and resocketing six times or more. At least two laps of rope must be on the drum when the cage, car, or skip is at the bottom of the hoist after the last cutting has been made. Ropes used on shafts or slopes for handling men must be in one piece from end to end and not spliced. Ropes used on slopes where men are not handled and on haulage ways may be spliced, but the splice must always be made sufficiently long to allow the strands to lock well into one another.

Directions for splicing rope may be obtained from any wire-rope manufacturer. They are the result of much experience and testing and should be followed exactly when making a splice.

In balanced hoisting, the length of the two ropes must be so adjusted that when one cage or skip is at the top landing the other will just rest on the bottom.

Any slack rope will cause the cage to start with a jerk, especially if the engine is started rapidly. This jerk, repeated with each hoist, causes severe stress in the rope and will soon result in serious injury to it.

The effect of the jerks may be considerably diminished by interposing springs between the rope and the weight of the cage.

As the rope stretches the slack should be taken up before it becomes too great. When the rope is new it will be necessary to take up the slack rather often, but as the rope is used it stretches less and need not be adjusted so often.

Sheaves and Drums.—Sheaves and drums must be at least as large as the minimum size recommended by the rope manufacturer and should be as large as conditions permit. Sheaves must be well balanced, as light as is compatible with strength—in order to cut down inertia in starting and stopping—and should have well-oiled babbited bearings.

In good practice, the diameter of sheaves should be 66 to 100 times the diameter of the rope. Ropes made of large wires and steel of high tensile strength require larger sheaves than the minimum specified for that size of rope. If the sheaves are heavy, poorly balanced, or the bearings are not in good condition, the rope will slip on the sheave at starting and stopping, with resultant wear. Sheaves with smooth, well-chilled iron throats or with rubber-lined throats will last longer and wear the rope less than those with rough, soft-iron throats. The plane of rotation of the sheaves must be exactly in the plane of the entering and leaving rope, to prevent chafing and wear of the rope.

Position of Drum.—The hoisting drum must be so set that the maximum fleet angle will not cause the rope to crush against or climb upon the rope already on the drum or rub against the sides of the groove of the sheave or the grooves of a grooved drum. Usually it is advisable to make the drum long enough to carry all the rope in one layer, in order to lessen the wear and crushing of the rope.

The maximum fleet angle will vary with the size of rope, and with the size, and shape, and length of the drum. An angle of 1½° on either side of a plane passing through the center (hoisting) line of the shaft or the slope and the sheave, is permissible for ordinary proportions of rope and drum. The fleet angle for extra small or long drums should be calculated for each drum.

Idler Sheaves and Rollers.—On slopes the rope must be kept from dragging on the ground by rollers or idler sheaves. These should be light, true, and supported on easy-running bearings to make them start and stop easily. The rope must be prevented from rubbing against the side walls, roof, or bottom at curves, by a series of small rollers or sheaves so placed as to cause only a small reflection angle at each roller. The diameter of such turn sheaves or rollers should be at least eight-tenths of the deflection angle times the diameter of the rope.

Handling and Storage of Rope.—Rope must be stored in a dry place; it must not be kept in a place so hot as to destroy the hemp core. If a rope is stored outdoors, the reel must be raised off the ground and well protected from the weather. In moving a reel of rope the bearing should always be on the flanges of the reel and never on the rope. To uncoil the rope, the red should be mounted on a horizontal support and allowed to revolve as the rope is drawn off. A rope must never be pulled up over the flange of the reel when laid on its side. A rope must never be allowed to kink. Before the load is attached a rope must be hung loose in a shaft and allowed to twist or untwist as much as it will under its own weight.

Attachment of Rope to Its Load.—The rope may be attached to its load by means of a socket, or it may be bent back on itself to form an eye and the loose end clamped to the rope with rope clips or clamps. Properly done, the former method of attachment develops the full strength of the rope, but it has several disadvantages. Poor workmanship is concealed, showing only when the rope slips or breaks in the socket; it can not be readily inspected; the rope is rigidly held in the socket and the effect of bending is concentrated just above the socket; and it is much more difficult to make. The latter method, fastening by clips, develops, at most, only about 85 per cent of the strength of the rope—usually not more than 80 per cent; bruises and crushes the rope where the clips are applied, and is liable to slip; but it can at all times be readily inspected and requires little skill in making. Rope makers, however, recommend the socket method of fastening, and if properly made it never fails. After either a socket or clamp attachment is made it must always be tested by making several trips under a heavy load before men are allowed to ride.

The method of making the socket joint is as follows: The rope should be securely seized or bound at the end with soft iron wire before the end of the rope is cut square. An additional seizing should be placed on the rope a distance equal to the length of the socket from the end. After the rope is trimmed off, the seizing on the end of the rope should be taken off, the rope opened down to the second seizing, the hemp center cut out and the wires broomed out. That is, they should all be untwisted but not straightened. Then the wires should be thoroughly cleaned in benzine, naphtha, or gasoline, as far as they are to be inserted in the socket, and then dipped in commercial muriatic acid for 30 to 60 seconds until the acid has cleaned each wire. Next, the rope end should be dipped in boiling water, to which a small amount of soda has been added to clean off and neutralize the acid. Then the rope end is inserted in the socket and warmed, if the temperature is below 65° F., to prevent cooling the zinc too rapidly. The socket is placed with its axis vertical and coinciding with the axis of the rope, the bottom is sealed with clay or putty, and molten zinc or spelter, heated to a temperature that will just char wood, is poured into the socket until it is full. The socket should preferably be forged from one piece of soft iron, without welds.

The clamped attachment is made as follows: The rope is bent back over a thimble of the proper size and the loose end clamped against the long end of the rope with the proper number of clips. The Crosby type of U-bolt-and-drop-forging clip has proved most satisfactory. The clips should be spaced a distance equal to six times the diameter of the rope apart, the drop forging being against the long end and the U-bolt against the loose end of the rope. The number of clips required to develop approximately 80 per cent efficiency of the rope and the proper length of wrench to tighten the bolts are given in the table.

NUMBER OF CROSBY-TYPE ROPE CLIPS REQUIRED TO DEVELOP 80 PER CENT OF STRENGTH OF 6-19 PLOW-STEEL ROPE.

Diameter of rope. Inches.	Number of clips.	Length of wrench to tighten bolts. Inches.	Efficiency. Per cent.
¾	5	18	77.39
⅞	5	18	79.13
1	5	24	77.89
1⅛	5	24	80.00
1¼	6	24	82.15

The clips must be carefully inspected each day and tightened if they show any signs of loosening through the stretching of the rope.

Renewal of Rope Fastenings.—If one broken wire is found in the rope at the fastening, the fastening should be cut off and renewed.

Even if no broken wires are found the rope must be cut off and the fastening renewed periodically, as this is the weakest part of the rope and most liable to suffer from bending and vibrating stresses. The length of time between renewing fastenings should vary with the life of the rope. The following table gives the period recommended in "Rules and Regulations for Metal Mines":

TIME INTERVAL PERMISSIBLE BETWEEN RESOCKETINGS FOR ROPES OF VARIOUS EXPECTED TERMS OF SERVICE.

Average length of service. Months.	Time between resocketing. Months.	Average length of service. Months.	Time between resocketing. Months.
6	1	18	3
8	1½	21	3½
10	2	24-36	4

A piece of rope equal in length to half the circumference of the sheave should be cut off when a fastening is renewed, so as to bring a new part of the rope in contact with the sheave where the wear is most severe.

After three years in service, even if idle, rope may not be used unless tested for ultimate tensile strength.

Unlay the piece of rope cut off and examine the inside wires for corrosion and wear. If they are broken, badly worn, or corroded, cut off another piece and examine it. If a considerable length of rope is in bad condition, the rope must be discarded.

At some mines it has proved advisable to turn the rope end for end after it has been in service some time, thus equalizing the wear on the two ends.

If the same size rope is used in two shafts, in one of which men and material are hoisted, and in the other material only, it is well to use a new rope first in the former shaft until it shows signs of wear and then put it in the latter and wear it out there. Likewise a rope can be used first on a shaft and then worn out on a slope or haulage way.

Safety Chains.—Where the height of sheave above the landing permits, safety chains attached to a clamp a short distance above the socket may be used as an additional precaution. The clamp should depend only on friction to prevent its slipping on the rope and it should not be roughened to grip or distort the wires of the rope. The rope must not be heated by pouring lead into the clamp. The clamp should never rest on the socket and the safety chains should be slack so the weight of the cage comes on them only when the socket or drawhead has been broken.

Attachment of Ropes on Slopes.—When the rope must be uncoupled from the cars, it may be attached by a socket and chain or by a shackle. But when the rope is permanently attached to the car, it is safer to pass the rope entirely around the car, clamping it to the car at various places, and to clamp the free end of the rope to the rope above the car.

Lubrication of Ropes.—A hoisting rope should be considered as a piece of machinery, having many wearing surfaces that must be thoroughly lubricated. The lubricant should consist of oils and greases that will penetrate between the wires and strands, and should not harden on the outside. A lubricant that hardens is cracked while bending over the sheaves and drums, so that moisture can penetrate to the center and cause internal corrosion.

Tar should never be used; it forms a hard shield on the outside of the rope and does not penetrate and lubricate the inner parts.

If possible, the rope should be lubricated when dry, so as to give the lubricant a better opportunity to penetrate the core and to adhere to the wires.

The lubricant must be applied often enough to keep the wires well covered and to keep the hemp core from drying out. All the accumulated dirt and gummed lubricant should be cleaned from the valleys between the strands of the rope so that the fresh lubricant can penetrate.

The rope may be cleaned by scraping and the use of a wire brush, or with a special device that permits a great number of jets of compressed air to play on the rope, removing all old lubricant and dirt.

The lubricant may be poured on or applied with a brush, but the most thorough and economical method is to apply it with a special device by which the lubricant is applied to all sides of the rope and the excess wiped off. For vertical ropes this device consists of a box and for inclined or horizontal ropes a trough that may be clamped around the rope, allowing the rope to pass through. This box is kept filled with the lubricant and the rope passing through it is covered on all sides with the lubricant. A wiper on the upper end of the box wipes off the excess and returns it to the box.

Inspection of Hoisting Ropes.—Hoisting ropes should be inspected at least once a day and their condition noted and recorded by a competent man, who must be held responsible for the condition of the ropes.

For the daily inspection, he should stand at the head of the shaft where he can see and feel the rope as it is hoisted past him at a speed of not more than 50 ft. per minute. He must inspect one rope at a time, examining it and its connections carefully. He must note the amount of wear of the wires, the stretching of the rope, broken wires, etc., and as soon as he finds dangerous conditions the rope must be replaced.

Special attention should be paid to the rope just above the socket; at the clamps and safety clamps, if these are used; where the rope rests on the sheaves, and where it leaves the drum at each end of the hoist.

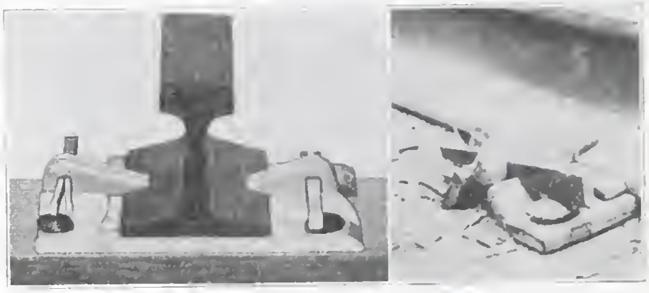
Rules for Discarding Ropes.—No standard rules for discarding ropes have been made; they vary with different conditions and in different localities. Various rules for discarding ropes are based on (a) the stretch of the rope, (b) the number of broken wires in a given length of rope or of the entire rope, (c) the amount of wear of the wires at the crown of the strands, (d) the length of time the rope has been in service, (e) the number of trips, (f) the tonnage, or (g) the ton-miles hoisted by the rope.

In the absence of more definite rules for discarding ropes, according to American practice, the following, quoted from "Rules and Regulations for Metal Mines," are suggested:

> Safety factors must never fall below 4.5. Ropes of standard construction shall be discarded when there are six broken wires in one rope lay, when wires on crown are worn to 65 per cent of their original diameter, when there are more than three broken wires reduced by wear more than 30 per cent in cross section, and when marked corrosion appears.

A New Tie Plate

A new form of tie plate described in "Railway Maintenance Engineer" has claimed for it two useful purposes in addition to the ordinary purposes, in that it prevents the spikes from lifting, and that it provides for shifting the rail to take up flange wear on curves without redriving any spikes or moving the plate. This new tie plate is known as the McSafety tie plate, and is manufactured by the Railway Safety Tie Co., Milwaukee.



Two Views of New Tie Plate.

In this new appliance the rail is held in place by a special fastening entirely independent of the four spikes that hold the plate down on the rail, although a portion of the fastening is so located as to offer an obstruction to the withdrawal of the spikes from their holes. The tie plate proper is cut from flat steel or iron plate. Each end is split in the middle by a vertical cut extending in about 2½ in. from the edge. The two edges of these cuts are bent up to an angle about 45° so as to separate the edges about 1 in. This arrangement forms projections on the upper surface of the plate which restrain the rail against a sidewise movement. The main purpose, however, is to form the sockets for the rail clamps. These are small forgings with a nose that projects over the top of the rail flange and a wedge-shaped base that fits into the recess under the plate formed by bending up the edges of the cut. The rail clamp is kept in place and held in bearing on the rail flange by a split key driven through a slot in the clamp and passing over the upturned edges of the plate which are also slotted slightly to prevent the key and clamp from backing away from the rail. This key, when in position, passes directly over the two spikes that hold down the plate on that side, so that the spikes can raise but a very small amount before being stopped by the key.

The device has one further feature. The distance between the interior faces of the two bent-up portions of the plate on the two sides is slightly greater than the width of the rail base. This excess width, ¼ to ½ in., is taken up by inserting a flat strip of steel that fills the space snugly. When installing tie plates of this kind on a curve the plates for both the inside and outside rails are installed with these strips of metal on the gage side of the rail. As the outer rail of the track becomes flange worn, thereby increasing the gage distance, these strips of metal on the tie plates of one rail, and later on the other rail, can be transferred to the outer side, thereby decreasing the gage distance by an amount equal to the width of the strip. Thus means are afforded for adjusting the gage without disturbing the tie plate or the track spikes.

This tie plate has been put in service for a few rail lengths on curves on the C. & N. W. Ry. and the C., M. & St. P. Ry. respectively, and have stood up satisfactorily under about a year's trial, under very heavy traffic conditions.

Limiting Features of Chilled Iron Wheels

A valuable study of the chilled wheel in its various aspects has been prepared by Mr. Geo. W. Lyndon, President, and Mr. F. K. Vial, Consulting Engineer, Association of Manufacturers of Chilled Car Wheels, and is quoted in a recent issue of the Electric Railway Journal, from which the following is taken:

The life of chilled iron wheels is reduced somewhat, due to the fact that the tread of the wheel is used for applying the brakes to retard the speed of cars. These braking operations develop high temperatures in the tread of the wheel in a short time, producing thermal cracks regardless of the type of metal of which the tread is composed. The coefficient of friction between the wheel and the rail is very irregular, which causes the wheel to slip and cause flat spots. The friction of the brakeshoe is also of variable quantity and depends upon the velocity of wheel rotation and shoe pressure. At 10 miles per hour, the coefficient of friction in a modern brakeshoe will reach 40 per cent or more. With a coefficient of friction as high as this the tendency to skid is very great if the friction between the wheel and rail is very much less. Some average values for the coefficient of friction between the wheel and rail under different conditions are: clean dry rail, 20 to 25 per cent; clean, thoroughly wet rail, 18 to 20 per cent; oily and moist rail, 15 to 18 per cent; sleety rail, 15 per cent; snow-covered or frosty rail, 10 per cent.

A comparison of these values shows why the number of flat wheels is very much greater in winter than in summer. The percentage of slid flat and comby wheels developed in January and February is easily three times as great as that for July and August.

Wheels of equal circumference should be selected for mounting on the same axle, as this materially improves the wheel performance, and at the same time reduces train resistance.

If one wheel is of a tape-size ⅛ in. greater than its mate the result will be a slippage, when in service, of 6 ft. per mile, and if each wheel is expected to give a performance of 60,000 miles the slippage will be 360,000 ft. or approximately 70 miles, providing the difference in diameter remains the same as when the wheel went into service. This latter assumption, however, will not hold, for the slippage reduces the diameter of the smaller wheel so that the difference is continually growing greater, thereby hastening the time when the wheel must be removed from service on account of wear.

Not only does slippage shorten the life of the wheel but, on account of the difference in diameter, the small wheel grinds the rail and a sharp flange is the result. The continual grinding against the rail also very materially increases train resistance, rail wear and the tendency for derailment on curves having worn rails.

Another common defect in wheels is known as "shellout." Years ago it was supposed that shelling occurred on account of defects in the metal in the tread of the wheel; that possibly there was some foreign material, as slag or sand, imbedded in the metal which gave rise to this defect. It was found that the defect existed only in the class of service having maximum amount of skidding and under equipment of considerable weight. It was also found that where a shelled spot occurred in one wheel the mate wheel had a similar defect in the same plane.

The conclusion reached from this study was that the tremendous amount of heat generated at the small contact area between the wheel and rail during the period while the wheel is sliding is responsible for the peculiar result. The metal at this spot is heated almost to the melting point and is immediately cooled, giving it a very high temper. The subsequent pounding on the rail causes the metal to disintegrate, starting at the surface at the center and increasing in depth as the disintegration recedes from the center. This condition is aggravated by the improper boring and mounting of wheels, and also by irregularities in braking power between different cars. irregularities in the equipment itself arising from unequal piston travel, improper brake hangers and other improper adjustments.

The amount by which a wheel may be worn in tread before removal from service is left largely to the judgment of the car inspectors. The idea behind the M. C. B. rule on this point is that when a wheel is sufficiently worn to permit the rim to project below the top of rail, where it is likely to receive blows from frogs and crossings, or when the flange becomes so high that the apex is likely to strike the bottom of flangeway, it should be removed from service. Wheels that are excessively hollow are likely to damage tracks and crossings on account of the overhanging rim, and of the high flange, which causes excessive pounding and rapid deterioration of the track at these points.

It is the practice in track work to allow a minimum of ⅝ in. for flange clearance at the bottom of flangeways in frogs, crossings, guard rails, etc. This allows the tread to wear down ⅝ in. before the flange will strike frog and crossing fillings on new rails.

In regard to the amount a wheel shall be worn hollow, the M. C. B. Association proceedings for 1905 recommend that wheels be allowed to wear down ⅜ in. before they are condemned unless worn through the chill. Wheels of the ordinary taper can be worn ⅜ in. from the original contour at the throat befort they can become worn 3/16 in. hollow. It is also evident that if the rim wears down, a total of more than ⅜ in. can be secured before the wheel is worn sufficiently to condemn it. It is also evident that it is possible to modify the taper and especially the drop-off taper in such a manner that more than ⅜ in. wear can be secured before the wheel is 3/16 in. hollow.

Cost Units for Railway Switches

The following data relate to switch installations in Detroit, Mich., for the Michigan Central R. R.:

Cost of material in switches from ledger account.

90-lb. rail:	
Number of switches installed	2
Highest cost per switch	$197.28
Lowest cost per switch	195.82
Average cost per switch	196.55
80-lb. rail:	
Number of switches installed	32
Highest cost per switch	$274.90
Lowest cost per switch	142.02
Average cost per switch	178.17
65-lb. rail:	
Number of switches installed	24
Highest cost per switch	$222.19
Lowest cost per switch	131.70
Average cost per switch	163.74
70-lb. rail:	
1 installed, cost	$155.54

Cost of material in industry tracks. Exclusive of switch material.

Number of jobs	35
Total length of track laid, ft.	30.933
Highest cost per foot	$1.3094
Lowest cost per foot	.5578
Average cost per foot	.7950

Installing switches, laying switches and setting concrete dumping posts.

Installing switches:	
Number installed	59
Lowest cost of installation	$16.06
Highest cost of installation	79.96
Average cost of installation	45.50
Laying track:	
Number of jobs	35
Total length of track, ft.*	30,281
Average length per job, ft	865
Lowest cost per lin. ft	$0.0577
Highest cost per lin. ft	.2545
Average cost per lin. ft	.1488
*Exclusive of switches.	
Setting bumping posts:	
Number set	17
Largest number on one job	7
Smallest number on one job	1
Average number on one job	1.7
Highest cost per post	$6.40
Lowest cost per post	2.01
Average cost per post	4.21

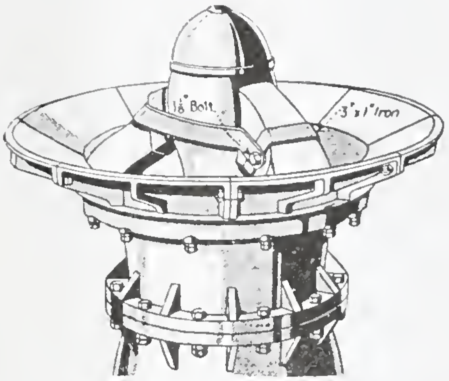
The above information has been furnished us by Mr. A. M. Van Auken. Assistant Engineer. Monon Route.

A 225-Mile Oil Pipe Line.—Members of the engineering and construction staffs of the J. G. White Engineering Corporation, New York, which has been awarded the contract for 225 miles of the White Oil Corporation's pipe line, have made a local inspection and survey of the proposed route. The present plans for the pipe line, which will extend from Houston, Tex., to the Ranger, Desdemona, and adjacent oil fields, contemplate the use of 8-in., 29-lb. pipe, with a capacity of 20,000 bbl. of crude oil per 24-hour day; the line to be operated at a pressure of 700 lb. per square inch. Pumping stations will be located at intervals of approximately 40 miles. The equipment of each station will consist of three duplex, double acting, outside packed plunger power pumps, direct driven by three Dielesel type crude oil engines. According to preliminary estimates the cost of the work approximates $5,000,000.

Suggestions for Repairing Rock Crushers

Rock crushers are usually designed to stand all the work they may be called upon to perform. However, they are subject to about the hardest service of any equipment in a crushing plant, and as a consequence repairs will be necessary sooner or later. Useful suggestions for making them are given by Mr. Charles Labbe in the Engineering and Mining Journal, from which the matter following is taken.

In most crushers the crushing jaws can be changed end for end. When worn at one end, which is mostly the lower end, taper bolts must be drawn very tight; and if the jaw plates have a chance to move sidewise it is best to wedge them tight, or, better, pour zinc to keep them in place. If the pitman cap studs break often this is caused by the back toggle being set on the wrong slant. The toggles must point down toward the pitman, and worn toggle and toggle seats must be taken out and overhauled at the machine shop. There must be plenty of head room at the crusher, and a crawl with chain block must be installed even before erecting the crusher. Such an insallation will pay for itself at the first repair. Over large crushers it is imperative.



Emergency Repair of Gyratory Crusher.

In the gyratory rock crusher a common repair is the babbitting of the eccentric. A special sleeve is always provided, thus simplifying the job. The old babbitt is chiseled or melted off, the sleeve clamped on and the babbitt poured in. As soon as cool, the sleeve is removed and the oil grooves are cut. The concaves must be replaced when worn to a safe limit. To take them out, the first one (which is the hardest) must be shot out with powder by boring a small hole in the zinc. Sometimes blasting can be avoided if by careful examination a loose concave can be found by trying with the hammer, the zinc chiseled off so as to let drive a sharp moil, and then a crowbar used. To put in new concaves, a guide ring is often used, which facilitates the work. If none is at hand, each concave is braced to the head with a strip of wood. Clay softened with oil is used (as in general babbitting work) to prevent zinc from running out. Be careful that no foreign matter drops between the concaves, as it will impair the strength of the zinc and make boiling certain when pouring. The concaves will set tighter if they are heated before pouring.

To take up the wear and to keep the crushing uniform, the shaft is raised, but when the lower edge of the crushing head comes above the lower edge of the concaves nothing can be gained. Either the concaves or the head must be changed. To take the head off, it is best to remove the entire shaft to the machine shop, because, as a rule, it is tight, and often the hydraulic press must be used.

In some crushing plants a duplicate shaft is kept with a different head. The one already used is put in when a new set of concaves is placed, and when the concaves are somewhat worn the shaft with the new head is put in. Thus the adjustments for uniform crushing are easy and a head can be changed at the shop when convenient.

A tedious repair is the replacement of a broken shaft; and a broken spider is as bad, if not worse. In this emergency a clamp must be forged in place to fit around one arm near the shaft bushing, another clamp fitted at the lower part of the broken arm, and a strong draw bolt put on each side. But in places where big rocks hit the spider, bolts must be omitted. A piece of flat iron is heated and bent in place around one arm, extending to the lower part of the other arm; then both ends are fastened with a bolt, as shown in the illustration. The heat must be kept on the sides of the clamp while tightening the bolt. In cooling, the contraction brings the broken parts together.

Suggested Improvements in Waterproofing Railroad Structures

After reviewing at some length several systems of waterproofing in vogue, Mr. Joseph Ross, C. E., in a paper before the Municipal Engineers of the City of New York, gave some suggested improvements in the way of employing some materials not commonly used for waterproofing subways and other structures. Various modern systems of waterproofing were discussed, and after pointing out the limitations of each system Mr. Ross offered the following suggestions in the hope that they might have in them the possibility of progress.

The disadvantage of a felt membrane is that it lacks in tensile strength or stretch. A cotton drill membrane, on the other hand, is too expensive for its relative efficiency, while an open mesh jute fabric membrane has the disadvantage of requiring very careful workmanship in the mopping process to insure complete watertightness; this is especially difficult to accomplish on vertical surfaces. These and other objections to the foregoing materials when used alone practically disappear when two are combined so that they alternate in the membrane. In fact, the most efficient and economical membrane is one composed of felt and cotton drill or jute fabric, for then strength and initial, as well as permanent, water-tightness are secured.

In view of the occasional breaks and other difficulties experienced with the use of felt, jute and cotton fabric membranes, due either to deterioration or insufficient strength, it is suggested as practicable to substitute a wire-cloth netting or metal lath as reinforcement for the membrane. This metallic reinforcement should, of course, be coated with a preservative paint not deleterious to the binder compound. It could be applied in the same manner as felts and fabrics are now applied, but not as many plies would be needed. For three plies of felt or fabric one ply of the wire mesh could be substituted, but the total thickness of binder used therewith should remain the same as in the former. For this purpose a mastic form of binder or a binder containing some inert fibrous filler would be better suited than a pure coal-tar pitch or asphalt. Such a compound could be made by incorporating a small quantity of shredded asbestos, cow's hair, or oakum in pitch or asphalt.

A new method of preparing a waterproofing membrane has been suggested, namely, to have the membrane come in ready-made sheets on the work. This finished membrane is to be formed of sheets of felt or fabric of the largest practicable size, say, 4 ft. by 8 ft., consisting of not more than four plies combined with asphalt or coal-tar pitch (of the proper consistence) as binder. These composite sheets should be ¼-in. thick, have a prepared lap of at least four inches on all sides, and be delivered on the work properly crated. Their preparation in a factory could be easily accomplished. The ready membranes might be used to good advantage on subways or other large and difficult engineering works if a good system of angles and connections with the flat work could be devised.

Another form of ready membrane can be made of flat or corrugated sheet iron, completely covered and cemented with one or two plies of ordinary felt or asbestos sheeting on each side. The flat sheets may be used on horizontal surfaces and the corrugated sheets on vertical surfaces. The method of application would be the same for both—that is, applying and holding the sheets in place until the joints could be properly lapped—and cemented. These ready membranes would be very water-tight in themselves, the only vulnerable parts being the joints. But it is certain that the joints could, with a little extra care and precaution, be easily protected and made as water-tight as the sheets proper. The adoption of either of these methods and materials would result in a great saving of field labor and equipment.

An efficient substitute for either felt or fabric membranes would be a sheet-lead membrane applied over a sand cushion on horizontal surfaces and dirctly against the masonry on vertical surfaces. It compares exceptionally well in durability with any of the other materials. It is, however, much more expensive and has not been used often enough to demonstrate its entire reliability. By its use the time of application would be considerably reduced as compared with other membranes as ordinarily applied. But here, too, the joints would require the best workmanship and closest inspection.

An envelope of compact clay between concrete surfaces would also be an effective substitute for the membrane or mastic systems. This material has been used in tunnels in the form of layers, 4 in. thick, surrounding the outside of the structure. In some cases the clay was mixed with cement in equal proportions, and this, too, proved a satisfactory waterproofing medium. The use of the clay envelope, however, would require considerably more excavation, and the work of application would be no less exacting than required with the other two systems. Its application and efficiency would be enhanced by using the cement gun.

An improvement worth considering in connection with the customary two-course brick-in-mastic envelope in which the bricks are laid on their largest bed and which has a maximum thickness of 5 ins., would be a single course of brick-in-mastic with the bricks laid on their narrow side. This would produce an equally good water-tight layer with a maximum thickness of but 4 in. and would result in a saving of 22 per cent in cost of materials alone. A 4-in. brick-in-mastic envelope is sufficient to withstand any water-pressure that subways are generally subjected to. An improved mastic, composed of bitumen, sand, mineral dust and a small percentage of long-fibre asbestos, used in connection with this single course, would add tenacity to the envelope. The amount of excavation and the labor cost would also be reduced somewhat. In place of brick for brick-in-mastic, porous tile blocks, 4 in. by 8 in. by 1½ in. (this being the smallest size made) may be substituted and embedded in mastic in exactly the same way as the brick. Two courses of tile block and mastic would give a maximum thickness of 3½ in.; a single course, with the tiles laid on their largest bed, would give a maximum depth of 2 in. This thickness is equivalent to a 15-ply felt or fabric membrane, but, of course, it has not the same elasticity or tensile strength.

Another alternative for brick-in-mastic—one which at present is extensively used for waterproofing railroad bridges and occasionally subways—is a reinforced, bituminous mastic sheet of from ¾ in. to 1½ in., in thickness. The mastic for this layer is made in the same manner as the mastic hereinbefore mentioned for brick-in-mastic, except that less bitumen is used, and grit is often included in the mineral aggregate. A sheet of this mastic 1 in. thick affords ample protection against any water-pressure that subsurface railroad structures are usually subjected to. One difficulty connected with the use of a mastic sheet for waterproofing is that it is easily cracked. This inherent defect is mitigated by introducing a wire mesh or wire cloth between equal thicknesses of mastic forming the sheet. The use of sheet mastic as against brick and mastic is that it permits a reduction of from 3 in. to 4 in. of excavation, takes up less room after application, and is not as expensive as brick and mastic courses.

Another alternative for brick-in-mastic, though of limited adaptability, will be found in the application of a 2-in. or 3-in. envelope of a mixture of clay and cement applied by means of the cement gun. This mixture and methods of application, if properly carried out, create a dense, impervious blanket about a structure. This blanket, too, is not immune to cracks, especially those due to settlement or vibration, but this weakness may be considerably reduced by proper reinforcement. This method would eliminate the need of the usual sand wall in rock excavation.

Lastly, for waterproofing subways located above mean-high or ground-water level an addition of 10 or 15 per cent of hydrated lime to the concrete would be ample, even at stations where watertightness is imperative, and certainly more economical than the usual steel-bar reinforcement of the concrete between stations; however, a membrane applied around the structure at stations to protect the costly decorative interior from possible defacement is most advisable.

Compensation of Engineers of St. Louis Will Be Increased.—A bill providing for increased compensation for professional engineers employed by the city of St. Louis has been passed by the board of aldermen of that city. This bill was prepared by the municipal section of the St. Louis Chapter of the American Association of Engineers last spring, and its passage is the culmination of a campaign which as been waged since to have it enacted into law.

Rental Charges for Contractor's Equipment Based on Capacity and Power Units

A committee of the Master Builders Association of St. Louis has recommended that rental charges for contractors' equipment be based on units of capacity or power. If the recommendations of the committee are adopted one schedule of rental rates would apply in all cases, whether on a lump-sum job, on cost-plus work, in renting from another contractor, or in renting from an equipment concern.

The recommended provisions and charges for plant rental, according to a weekly news letter of the Associated General Contractors of America, are as follows:

The contractor will supply all construction equipment of every description for the proper handling of the work. For such construction plant, or parts thereof, as the contractor may own or furnish, rental will be charged at the rates mentioned below, and such construction equipment wil be carried on the contractor's regular payrolls for this work and as a part thereof at these rates, or as otherwise specified below for each and every working day, also for Sundays and holidays, if used. In the event of the contractor's equipment being used for a longer period of time per day than the regular working day, an additional pro rata charge of the scheduled rates will be made for such overtime as each item is used.

The duration for which rental will be charged, except as otherwise provided below, is from the time contractor's equipment is loaded on cars for shipment to the work, as shown by the shipping manifest, until contractor's equipment is loaded again for return to the contractor, unless other conditions are agreed to in writing, Sundays and holidays excepted unless used.

Charges for the use of such construction equipment as is desirable or necessary for the contractor to rent from outside sources will be made in accordance with the bills rendered by the suppliers of such equipment, together with all expenses in connection therewith, for which the contractor is liable.

Contractor's equipment will be shipped in good operative condition, and charges for ordinary replacement of parts or other repairs necessitated during the progress of the work will be billed at cost of such replacement or repairs. On rented equipment charges for repairs will be in accordance with the agreement with the owners of such equipment.

Under the item "Small Tools" are included all tools used, not scheduled below, including carts, wheelbarrows, shovels, picks, bars, wrenches, axes, drills, wire cables, ropes, rubber boots, and similar items, and a charge for the use of same will be made at a lump sum equal to 2½ per cent of the total amounts of the contractor's payrolls for this work.

All teams used for and on this work will be charged for and carried on the payrolls at the prevailing local rates.

Trucking, freight, express, and all other such items as may be incurred for the delivery to the work and reshipment back to the contractor, of all contractor's equipment, and all labor and expenses in connection therewith, and for the putting together, setting place and moving, together with the dismantling, moving, and reloading of all items of contractor's equipment for this work, will be billed in addition to the other charges mentioned above.

Equipment.	Daily Rental Charge.
Adding and listing machines	$ 0.25
Automobiles, passenger	1.00 per cylinder
Automobiles, trucks	5.00 per ton
Automobiles, tires, extra, each	0.01 per mile
Backfiller, power driven	7.50
Barges	0.01 per 100 sq. ft.
Boiler and 3-drum engine	0.30 per hp.
Boiler and 2-drum engine	0.25 per hp.
Boiler and 1-drum engine	0.20 per hp.
Boiler only	0.10 per hp.
Boring machine, wood	0.50
Bucket, tipple and bottom dump	0.02 per cu. ft.
Bucket, orange peel or clam	0.10 per cu. ft.
Cableways, without power	0.01 per lin. ft.
Cars, skip, wood	0.25 per cu. yd.
Cars, steel, 1 yard and smaller	0.02 per cu. ft.
Cars, wooden, side dump	0.25 per cu. yd.
Cars, standard, freight	0.05 per ton capacity
Cars, steel, side dump	0.35 per cu. yd.
Compressor, air—steam	0.02 per cu. ft.
Compressor, belt driven	0.01 per cu. ft.
Compressor, portable with power	0.03 per cu. ft.
Counterweight drum	0.50
Crusher, only	0.50 per ton hour
Crusher, with elevator screen	0.75 per ton hour
Cutter, bar, portable with power	4.00
Derrick, wooden	0.05 per ft. boom
Derrick, steel	0.08 per ft. boom
Derrick, traction	0.75 per ft. boom

Derrick, breast	0.40	
Derrick, circle swing	0.50	
Drill rig, portable	10.00	
Drill rig, small air	0.50	
Drill rig, steam	1.25	
Drill rig, Duntley electric	2.50	
Elevator, platform or bucket	0.50	
Elevator, with bins for concrete	0.75	
Engine, skeleton, 3-drum	0.20	per hp.
Engine, 2-drum	0.15	per hp.
Engine, 1-drum	0.10	per hp.
Engine, steam or gas	0.10	per hp.
Engine, derrick, swinging	1.00	
Engine, traction	20.00	
Excavator—Keystone No. 3	20.00	
Grader, belt, elevating	10.00	
Hammers, riveting	0.50	
Hood, elevating machine, hand power	1.00	
Leveling instrument, engineers'	0.50	
Locomotive, 36-in. dinkey	7.50	
Locomotive, standard gauge	15.00	
Locomotive, crane	1.00	per ton
Mixers, with power and side loader	0.30	per cu. ft.
Mixers, with power	0.25	per cu. ft.
Mixers, without power	0.20	per cu. ft.
Motorcycle	1.50	
Motors	0.10	per hp.
Motor boats	0.50	per hp.
Pile driver leads	0.05	per lin. ft.
Pile hammers, steam	0.02	per 100 lbs.
Pile hammers, drop	0.01	per 100 lbs.
Pumps, centrifugal, belt driven	....	per M. gal. hr.
Pumps, centrifugal, with power	....	per M. gal. hr.
Pumps, duplex and triplex	....	per M. gal. hr
Pumps, pulsometer	....	per M. gal. hr
Pumps, diaphragm, hand	0.50	
Pumps, diaphragm, with power	1.50	
Plow	0.50	
Rail	0.10	per ton
Rail bender	0.30	
Roller, horse or hand	1.00	per ton
Roller, power	2.00	per ton
Road machine	1.00	
Saw, no power	0.50	
Scraper, wheel	0.50	
Scraper, slip	0.25	
Sprinkling cart	1.50	
Steam shovel, revolving traction	30.00	
Sewer potter machine, no power	4.00	
Tamps, compressed air, for track	0.75	
Torch, acetylene	3.00	
Transit	0.75	
Trench diggers, to 24 in. width	....	
Tug boats	....	
Typewriters	0.20	
Wagons	0.50	
Wagons, float	2.00	

Crew, fuel and lubricants not included in these prices. Rental prices are per day based on manufacturers' rating for equipment.

Bituminous Paving for Highway Crossings

As evidence of an effort to reduce the cost and the maintenance of railway crossings of streets and highways as well as to conserve the use of lumber, a committee of the Roadmasters' and Maintenance-of-way Association submitted a report at the recent annual convention in which three methods of paving at the crossings are proposed and recommended.

As a preparation for the paving it is specified that the ballast must be cleaned out to 2 in. below the bottom of the ties for the width of the crossing and for 2 ft. outside the rails. The rails are painted with asphalt under the base and up to the underside of head, and the joints are bonded.

In the first method a mixture of hot asphalt and ½-in. stone is packed and tamped around the rails for a width of 8 in. on each side. The interior space is then filled with stone ballast up to the underside of the rail head, and well rolled or tamped. Fine stone is filled in to the level of the tops of the rails, road oil being sprinkled freely as the stone is placed, and the surface is finished by rolling and sprinkling.

In the second method, the asphaltic mixture along the rails is only 4 in. wide, while bituminous material is poured with the ballast filling and the ½-in. stone surfacing.

Under the third method, stone ballast is packed between the rails up to their heads. On this is laid a bituminous macadam composed of clean gravel or stone screenings up to ½-in. size and a 2:1 emulsion of road oil and water. Two gallons of this mixture are used for 1 cu. yd. of stone.

Traffic should be kept off for 24 hours, but if this is not possible the crossing should be watched and any ruts or patches smoothed out, until the material has hardened. Where paved crossings need only surfacing, about 2 in. of the old material may be removed and this bituminous macadam substituted.

The costs per crossing for the three methods, together with the ordinary plank crossing, are given as follows, at 1918 prices:

	Double-track crossing.	Single-track crossing.
1. Stone and road oil	$25.45	$11.95
2. Stone and bituminous	16.25	6.55
3. Stone and bituminous macadam	29.45	13.95
4. Plank crossing	56.00	25.00

The Engineer as a Public Servant*

By WILLARD BEAHAN,

Principal Assistant Engineer, New York Central Railroad, Western Lines.

We are engineers. What does that mean? Well, I suppose we may say, modestly and historically, that, as a rule, the engineer is a college man. We must then also say, if that be true, that in a majority of cases he has been educated in one of our great state universities; because, while we have engineering schools—very excellent ones—that are not state universities, yet the state university graduate is by far in the majority. In these state universities where young men are educated we are educated largely at public expense, especially in land grant colleges.

Now, my friends, if that be true, if we are educated at the public expense, as I see it, we are quite in the category of a graduate of West Point or Annapolis. Those men, we are proud to say, when war is declared, and when there is trouble in their line, while they may have gone out of service, while they may have been retired, at once volunteer because they feel that they owe a debt to their country for their education, for the uplifting chance they got, and they are always willing to extend their services.

So it is with us. The engineer is a public servant, not only by his profession but by his education and by the debt he owes his country. I never apologize for the necessity of driving an engineer into doing something for the public, because he owes it to the public. We owe more to the public than the lawyer or the doctor or any other professional man. Think that over. I believe I am right in it.

Now, if that be true, there is another fact that you must put beside it. The engineer was not only educated technically and to a considerable degree at public expense, but the engineer was educated for leadership. Some are not leaders, very true. Some are designing engineers. Some are research engineers. But not all West Pointers are leaders. General Seibert, I learned, has never considered himself that at all, but still, by and large, the engineer is expected, and rightfully, to assume leadership of his fellow men. By his training, by the opportunity which the public has given him, he has been put up on the mountain side of progress a little—a considerable—above the average of his fellow men. He will see the dawn of a new day. He will see the coming of the new light and the new conditions which surround us now clearer and quicker than his neighbor can be expected to see them. Haven't we seen it in this war in many ways over and over again?

I do not feel any burden arising from that, but to me it is a source of rejoicing. I well recall, back in my 'varsity days, a picture and a line under it. The picture was that of the Vaudois, in times of persecution, those Swiss mountaineers who kept the faith, the Waldenses, as some call them, and they really did believe that they held to the Christian faith when it was wiped out every place in the world. And these were the lines under this picture, which great and good Andrew D. White has given to us for our uplift and our benefit—you see I remember them over forty years. These are the words put on the lips of these people, these mountaineers:

"For the strength of the hills, we bless Thee, our God, our
Fathers' God,
"Thou hast made thy children mighty by the touch of the
mountainside."

Now, my friends, that is my conception of your profession and mine, and if I miss every other point here tonight, I want you to get that note, the note of leadership, the note of superior knowledge of the working conditions and the economic conditions and the social conditions of this hour, for you will do one of two things—you, as engineers, will lift or you will lean. And my duty here tonight is to adjure you to lift, for God knows there never was a time in the history of the human race when lifting was needed more.

We have men in our department on the New York Central Railroad that have not done an honest day's work since the war broke out, and their salaries in the thousands. Now put that in your pipe and smoke it. It is not news to us. I have told it to the chief engineer and he admits it. What are you going to do? He says, "I can't discharge them because the law is that way." But may God help them when the roads get back to private control, because they will see a new light.

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*From an address delivered before the Ohio Association of Technical Societies.

I have patience with the hobo when he acts that way, although I have a higher regard for a hobo than many have. I have all patience with the negro. He is but a grownup child. I cannot blame a foreigner who cannot speak a word of my language. We have mills in Pittsburgh where 50 per cent of the men do not understand a single word of English. I have patience with that sort of people. That is what we are here for, to lift and to guide and to lead. But the man who has a diploma from a state university, a land grant college, and who acts that way—he ought to be shot.

There is the head of a great labor union, my neighbor. I have heard him many and many a time, earlier than five years ago, say this: "What we want," referring to his brotherhood, his labor organization, "is more money in the pay envelope on Saturday night, and that is all we want. We don't care whether we have got a place to sleep or anything to eat. We don't care anything about this welfare work and the Y. M. C. A. at the end of the division to take care of the men. All we want is more money in the pay envelope Saturday night." Of course he was lying at the time. He knew it and so did I. What does he say now? He says, "This won't do. This is a vicious circle. We cannot have this any longer." He has seen a new light. He knows more than he did. Said he: "Why, this is what has brought on the high cost of living. We started the high cost of living on the rail roads. We were the worst sinners of all. We got scared before we were hurt, or even hit. We started this uplifting"—if you will call it such—this madness as I will call it, this midsummer madness.

The result is this, we are face to face with a sad condition, a menacing condition. Do not deceive yourself that we are simply having a lot of strikes on our hands. That is not the worst of it. The worst of it is that the men who head those unions and who have advocated these strikes in the years gone by, now see this, that the power that they have started has gotten entirely beyond their control and they are the men actively trying to stop this trouble and they do not know whether they can do it or not.

I stopped a gang of a hundred hoboes once who were going to hang a man, one of our men and these were our own employes. They couldn't get around me. The snow was too deep. I was alone. I explained to them and argued with them and talked to them like a big brother, like a Dutch uncle, and like an Irish washerwoman, and they all went back except fifteen. Not more than fifteen of the hundred had any resolution whatever in that direction, and that is a very big per cent. These fifteen were partly drunk. They wouldn't go back. I drew my toe across the snow path and stepped back. I had to talk to them for twenty minutes, and that is long enough to convince anybody except a meeting of this sort.

I said to them, "I am done talking. You say you are going to hang that man. Now come on." They commenced to sober up. I said to them, "The first man that crosses that mark will be killed." I was a deputy sheriff and it was part of my duty to quell rioting. I had a pistol, a 32, with five shots. I know there should have been six. There were fifteen who had remained but not more than five had courage to even approach the mark—not more than five out of the hundred.

Well, if you are able bodied, and you ought to be if you got through the university, do you mean to say to me that you will let three or five hoboes bluff you or drive you around over the country? Really you are not in very much danger. If you have been with those men for some time, plenty of them will not see you get hurt. Don't you know that?

This lawless element, and this is my point, numerically amounts to but little. Take out the foreigner who does not know what he is talking about or what is said to him, and the hobo element or the negro element is very small. And oh, if we had a little bit of backbone about us, if we had a few less lawyers and courts and a few less newspapers to write up what terrible fellows we are, we could handle this labor situation. It is only the froth, and some of the damnable things we have in civilization we have only because of the political methods that make it worth while to talk about it and to keep things in a permanent commotion. It is the question of votes. There is the trouble. You let men have that before they can read. They can vote before they know what our institutions are. Of course it is all wrong. This is the land of the free and the home of the brave, but it is costing us a lot to keep it so.

Testing Some Very Old Rails for Internal Strains and Transverse Fissures

As a contribution to the much-discussed subject of the cause of transverse fissures in rails, Mr. W. C. Cushing, Chief Engineer of Maintenance on the Pennsylvania Lines West of Pittsburgh, has given in Bulletin No. 218 of the American Railway Engineering Association, results of tests on some exceptionally old rails, long in service. To quote Mr. Cushing:

"If stored-up internal stresses in rails proceeding in combination from three principal components which affect them in service, namely:

(1) Cooling strains of fabrication,
(2) Cold-rolling strains from wheel loads,
(3) Direct stresses in track,

tell the whole story of the cause of the 'transverse fissures,' then it might be reasonably expected that rails especially long in service would be not only likely to have that type of defect, but would be almost certain to have it, particularly if the elastic limit of the metal were very low, thus reducing the ratio between it and the wheel load. The writer therefore made an investigation to study the subject from that point of view, and collected such rails as might be considered as fairly fulfilling the premises, after which they were surveyed chemically, mechanically, and microscopically at the Altoona Laboratory of the Pennsylvania Railroad."

The rails selected and their respective lengths of service were as follows:

English rails (wrought iron), Louisville Division	41 years
German rails (iron and steel pile), Long Island R. R.	45 years
P. R. R., Bessemer, Pittsburgh Division	25 years
P. R R., Bessemer, Columbus Division	22 years
A. S. C. E., Bessemer, Pittsburgh Division	10 years
P. R. R., Bessemer, Cincinnati Division	19 years

The severity of service in each case was of course not the same, the greatest severity being on the Pittsburgh Division.

All of these rails were carefully examined for transverse fissure defects, but none were found.

An examination of the German rails disclosed that they were rolled from slab-piled blooms, the layers consisting alternately of steel and iron with the vertical axis of the rails at right angles to the direction of piling. The tests showed that there was improper fusion between the layers.

Notwithstanding some high internal stresses, low elasticity and lack of homogeneity in the structure, found in some of the rails tested, these same rails had served under heavy traffic for 25 and 19 years, respectively, and a careful examination of an entire group of Bessemer steel rails failed to disclose any signs of transverse fissures.

It is reasonable to expect, therefore, that, if severity of service, especially by exceedingly heavy wheel loads, be the sole cause of the defect known as transverse fissure, these rails, after their unusually long service, and in some of the cases under the heaviest wheel loads in use, would be sure to be filled with transverse fissures. That such was proved by careful examination not to be the fact, that rails adjacent to and undergoing precisely the same conditions of service as those in which transverse fissures have been found do not have any, and that rails never put into service as well as those which have been in service have been shown by Waring and Wickhorst to contain microscopical cracks, seems to prove beyond a doubt that the cause, the real cause of transverse fissures must be sought in the processes of manufacture. The wheel loads are the instruments of development from the initial defects, and it is true that the service has become uncommonly severe.

A $4,000,000 County Road Letting.—Bids are now being asked by Maricopa county, Arizona, on one of the largest highway construction programs ever let at one time by a county. The work calls for the building of 278 miles of highways, for which a $4,000,000 bond issue has been authorized. The plans and specifications includes roads of concrete, asphaltic concrete and crushed rock with asphaltic concrete. The bids are to be opened at Phoenix, Ariz., on Jan. 12, by the County Highway Commission, of which A. F. Jones is secretary.

MANAGEMENT AND OFFICE SYSTEM

This section is published twice a month: (1) In the Waterworks and Hydraulic Monthly issue, and (2) in the Railway and Excavation Monthly issue. It covers what may be broadly termed "management engineering" as applied in the civil engineering and construction fields.

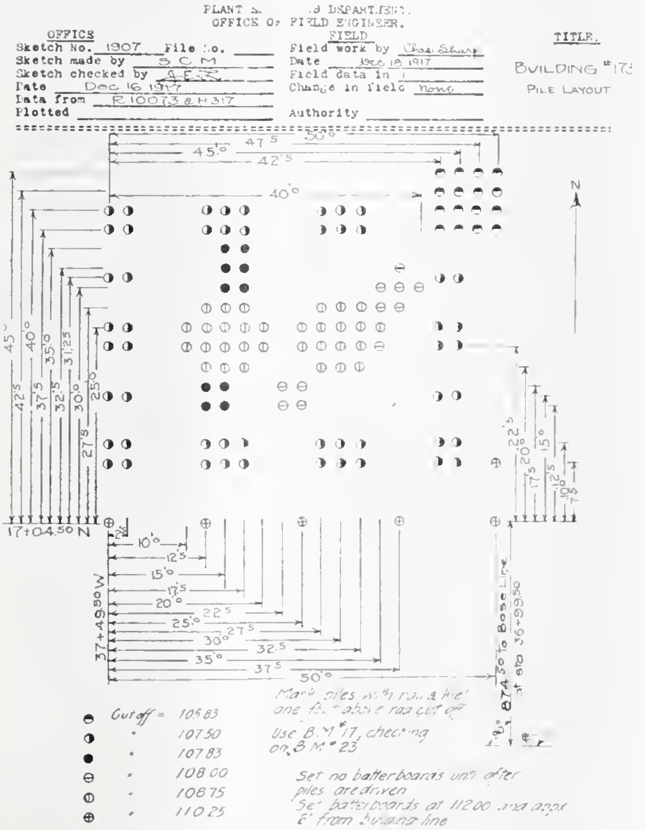
Advantages of Small Sketch Sheets in Supplying Information to Field Parties on Construction Work

By WALTER A. BOWEN.

While the loose leaf system for keeping field notes has been in use for sometime by engineers, the writer has not seen this system used elsewhere to furnish data to field men to the extent that he has developed it on a recent big war-time construction job.

This job was typical of many others under way at the time with the construction of shops, offices, warehouses, water, sewer, electrical, air and oil lines being rushed, and the field engineering parties in great demand by the construction forces.

All plans were furnished the field office by the main office several miles away. All structures, roads, utilities, etc., were located by co-ordinates, the general co-ordinate plan being revised almost daily during the first few weeks of the job. Detail plans of buildings did not show location or actual elevation of sills, pile cut-offs, etc., this information being furnished by the field engineering office from grade plans.


PLANT S. .S DEPARTMENT.
OFFICE OF FIELD ENGINEER.

OFFICE
Sketch No. 1907 File No. ____
Sketch made by S C M
Sketch checked by A E R
Date Dec 16 1917
Data from R 10073 & H 317
Plotted ____

FIELD
Field work by Chas Sharp
Date Dec 18 1917
Field data in ____
Change in field None
Authority ____

TITLE.
BUILDING #173
PILE LAYOUT

Cutoff = 105.83
" 107.50
" 107.83
" 108.00
" 108.75
" 110.25

Mark piles with round hole one ft. above rad cut off

Use B.M. #17, checking on B.M. #23

Set no batterboards until after piles are driven

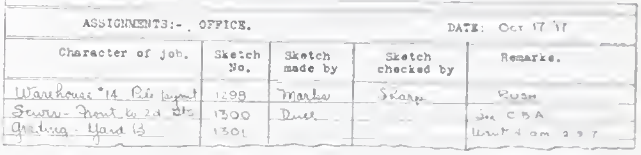
Set batterboards at 112.00 and appr 6' from building line

Fig. 1—Information Sheet for Field Men.

Because of these conditions, with the large number of field men employed, there being 20 parties of four men each, all information was furnished the field men on letter size white bond blue lined cross section paper or unruled vellum with a mimeographed heading as shown in Fig. 1. The sketches were drawn approximately to scale in pencil or ink and had all necessary information for the field party. Points requiring particular attention, such as varying pile cut-offs, etc., were shown in colored inks.

The compiling of these data from the plans brought to light errors or omissions in the layout which would have wasted much time of the field parties in having to return to the office for further instructions had the blue prints been used in the field. The field office was thus able to correct these slight errors or omissions in the minimum of time and with no loss of time for the field parties.

The draftsman making the field layout indicated on the sketch sheets only the necessary work to be done and the shortest way for the field men to properly perform it, which was another saving of time, as the party was not idle waiting for the chief to plan the work.


ASSIGNMENTS:- OFFICE. DATE: Oct 17 '17

Character of job.	Sketch No.	Sketch made by	Sketch checked by	Remarks.
Warehouse #14 Pile layout	1298	Marks	Sharp	Rush
Sewer - Front to 2d Sts	1300	Duel	--	See C B A
Grading - Yard B	1301			Wait for am 2 9 7

Fig. 2—Assignment Sheet for Office Work.

Another advantage was the small size, as the letter size sheets were easier to handle in the field than the large blue prints, particularly during cold or windy weather.

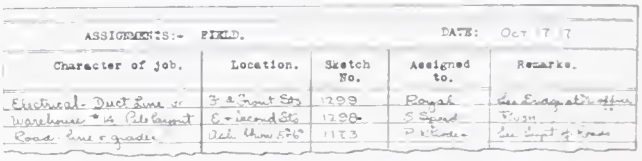
Sketches for the field men requiring considerable computing to secure the data were traced on vellum sheets headed as in Fig. 1, and the paper original filed, the field men using the vellum which was quite as durable as the paper. The computations were made on the original sketch sheet, but only the result of these computations was shown on the sketch traced for the field parties.

This system has also been found to save considerable time in furnishing the designing section with information regarding temporary structures which are to be converted into permanent buildings, in making insurance surveys or supplying them with the miscellaneous information which was required daily.

The field men taking these sheets into the field on work requiring the collection of considerable data, either fastened the sheets by thumb tacks to small drawing boards made from pieces of compo-board or in three-ring loose leaf canvas covered note books.

Carbon copies were made when on this class of work, the original being sent to the designing section and the carbon copy indexed and filed at the field office. The filling in of the headings gave the office a complete record of the sketch from its beginning to its return for filing.

The sketch sheets were filed in canvas bound loose leaf books holding 200 sheets, the limits of sketch numbers being marked on the back of the book.


ASSIGNMENTS:- FIELD. DATE: Oct 17 '17

Character of job.	Location.	Sketch No.	Assigned to.	Remarks.
Electrical - Duct Line &c	F & Front Sts	1299	Royal	See Engr at the office
Warehouse #14 Pile layout	E & Second Sts	1298	S Sharp	Rush
Road - line & grades	[illegible]	1173	P [illegible]	See Supt of Roads

Fig. 3—Assignment Sheet for Field Work.

Sketch numbers were taken by draftsmen from a letter size typewritten list of consecutive numbers posted on the bulletin board, the title of the sketch being written after the number showing that it had been assigned to a sketch sheet. When filled these sheets were filed in a loose leaf binder and the title added to the loose leaf alphabetical index.

According to the demands of the construction department, two to eight draftsmen were kept busy making these sketches or compiling data and making computations for them.

In order to handle the large number of requests for services of the field men, the writer kept assignment sheets for the field and office work with headings as shown in Fig. 2 and Fig. 3. These also fit a pocket loose leaf note book.

Data used daily by the field men were furnished on small blue prints 3¾ in. by 6¾ in. made from tracings or carbon backed vellums. This size was adopted due to many of the field men having loose leaf note books holding this size sheet and in which they kept field notes of minor importance.

The Stock Bonus Plan of the du Pont Co.

The E. I. du Pont de Nemours Co. for many years has been using a bonus plan, which is regarded as being one of the elements in the company's success. The company adopted the plan as a policy in order to reward in a special manner, those of its employes who have contributed in an unusual degree to the success of the company by their inventions, ability, industry and loyalty—a result which frequently cannot be accomplished through salary alone. It also desires to interest such employes as stockholders in its business.

In the Annual Report of 1918, Pierre S. du Pont, then president, speaking of the actual working out of the bonus plan, said:

"The officers and directors believe it has been of great value in securing and retaining at highest efficiency the best men in the explosives industry. The bonus plan furnishes for distribution among employes of recognized merit a number of shares of stock of the company each year. As the amount of this bonus stock is based on earnings, many shares were available for distribution during the years 1915 to 1918. In the years 1915, 1916 and 1917, there was awarded as B. bonus a total of 6,286 shares of common stock of E. I. duPont de Nemours Powder Co., 24,301 shares of debenture stock of E. I. duPont de Nemours & Co., 42,839 shares of common stock of E. I. duPont de Nemours & Co. For the year 1918, 8,006 shares of debenture stock of E. I. duPont de Nemours & Co., and 8,680 shares of the common stock of E. I. duPont de Nemours & Co. (cost value $3,162,493) have been awarded for distribution as B. bonus to 2,329 employes of the executive and finance committee and finally approved by the special committee of the board of directors. The total cost of these securities for the four years, 1915-1918, has been $16,379,914. The merits of the plan have been recognized by the officers and directors of the company and its predecessor for many years."

At the present time there are 7,203 stockholders of the company of whom 3,220, or 45 per cent are employes. Most of the employes have become stockholders by means of the bonus stock plan.

Awards according to the bonus plan are made under one or both of the following clauses:

Class "A" bonuses are given for inventions or other conspicuous service entirely irrespective of the company's earnings, each case being considered on its merits without regard to departmental lines or limitations as to length of service.

Class "B" bonuses are in the nature of profit sharing with those who have contributed most in a general way to the company's success.

The total value of stock at actual cost to the company, which may be awarded each year under class "B" is approximately 7 per cent of the surplus left from earnings after the payment of debenture stock dividend and 5 per cent dividend on the common stock. Class "B" bonuses are awarded the first of the year and can only be given to employes who have been with the company for at least two years, although exceptions, in special cases, to this rule—as to time of service—may be made if approved by an affirmative vote of three-fourths of the executive committee.

Recommendations for bonuses are made by the heads of departments who give the name and character of duties of each employe recommended, the amount of bonus recommended, the reasons therefore, and the name of the officials approving the same. These recommendations are acted upon by the executive committee.

The executive committee appoints a bonus trustee who has the management of all matters relating to the bonus granted. When bonuses are awarded, a certificate for the number of shares allotted to each beneficiary is issued in his name and delivered to the bonus trustee, who holds the certificate until they are finally delivered to the beneficiary.

The bonus trustee opens an account with each beneficiary, charging him with the par value of the stock awarded and crediting him each month, beginning with January of the year in which the award is made, with one-sixtieth of its par value. Thus, at the end of five years when the credits so made equal the debits the bonus trustee delivers to each beneficiary, who has remained continuously in the company's employ during that period, the certificates of stock free from all restrictions.

If a beneficiary leaves the service of his own volition, or is dismissed because of unsatisfactory service, that portion of his bonus represented at the time by the debit balance in his account reverts to the company and a certificate for the portion of his bonus represented by the total credits of his account are delivered to the beneficiary free from all restrictions, provided, however, that no fractional share is issued and that the company shall purchase any fractional share to which the beneficiary is so entitled for cash at par.

Upon the death of the beneficiary the bonus trustee delivers the certificate or certificates evidencing the total bonuses awarded him to the executor or administrator of his estate.

There are a number of other employes' benefits, such as the "Stock Purchase Plan," the "Merit Pay Plan," which is confined to workmen at the plants, and the group "Insurance for Employes."

Time Tests of Loading 65-lb. Rail on Flat Car by Hand

The following data were obtained on work done near Ypsilanti, Mich., on the Michigan Central R. R., on April 12, 1917. The gang consisted of the following:

1	foreman at	$90.00 per month
1	timekeeper at	75.00 per month
1	cook at	2.10 per day
1	water boy at	2.10 per day
15	laborers at	2.10 per day

The equipment consisted of two hand cars.

The gang was surfacing tracks near Milepost 29 until 11:30 a. m. It then knocked off for ½ hour for dinner. The transporting of the men consumed 40 minutes for a distance of 3 miles to a point (Milepost 32) on the main track opposite the pile of rails to be loaded.

The material loaded consisted of 102 odd lengths of used rail including 2,756 ft. of 65-lb. rail and 20 ft. of 80-lb. rail.

The labor time distribution was as follows:

Left mile post 29 at 12:00.
Arrived mile post 32 at 12:40.
Loaded rail and lumber from 12:40 to 3:45; this includes delays.
Left mile post 32 at 3:45.
Arrived mile post 29 at 4:10.

Delays in loading the rails were as follows:

	Minutes.
Stopped at Ypsilanti station for foreman to receive reports of trains	8
Removing hand cars from track	2
Walking from hand cars to where rails lay	5
Waiting for rails to be measured before placing on flat car	9½
Moving flat car about 10 ft.	3
Moving flat car about 2,000 ft. (rails were in two piles about 2,000 ft. apart)	22
Loading lumber	35

The later item involved the loading of 42 pieces of 3 in. x 10 in. x 16 ft. planks in a box car. The lumber lay opposite the pile of rails so no time was lost in moving from rail to lumber. The results of a test made to determine the time required to lift and throw 10 rails on flat car follow:

15 sec.	27 sec.
38 sec.	40 sec.
65 sec.	35 sec.
18 sec.	20 sec.
22 sec.	27 sec.

It will be noted that it took 307 seconds or 5 minutes, 7 seconds to load the 10 rails (25 to 33 ft. long). This gives an average of ½ minute for loading each rail. We are indebted to Mr. A. M. Van Auken, Assistant Engineer, Monon Route, for the above information.

Port Works for Chile.—The Chilean parliament on Nov. 28 authorized a loan of $25,000,000 for the construction of port works at Valdivia, Lebu, Constitucion and Talcalurano.

Improvements in Time Study Methods

Of interest to efficiency engineers or others concerned with time studies, is an article bearing the above title in the August number of "Industrial Management." The author, Mr. A. H. Chubberly of the E. I. du Pont de Nemours Co., says:

Those who are familiar with the methods followed by the average time-study man cannot help but realize that there is much chance for improvement. So I wish to point out a few improvements that will help time-study men to increase their own efficiency, and to make more accurate and a greater number of studies in a given time.

For certain purposes it may suffice to divide an operation into large enough elements to require only one entry every two or three minutes; for others, an entry may be required as often as seven or eight or more times in one minute. During the writer's experience in making time studies containing short time elements, the need has often been felt for a device to hold more than one stop watch, so that one could be stopped but not snapped back to zero while another could be used to record the time of the next element. It would then be possible to make entries on the time study sheet before the registering watch was snapped back to zero, and with such an arrangement it was thought it would be easier to make accurate time studies provided the arrangement for operating the two watches was not too cumbersome.

A Four-Watch Board.—A time-study board was devised to meet this requirement. This device has four watches. Three are decimal timers and one is an ordinary cheap day watch. The two watches on the left-hand side of the board are connected by a tandem control so that by operating a single lever the first watch is stopped and the second watch is started, and by operating the same lever in the opposite direction the second watch is stopped and the first watch is started. To snap either watch back to zero, the stem at the top is used.

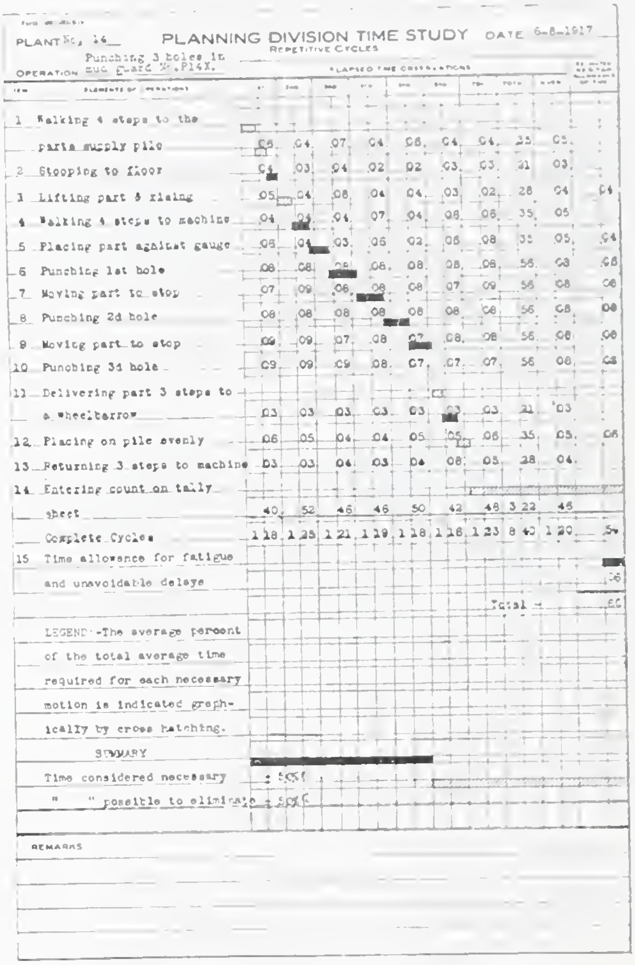
In making studies of repetitive operations, it is good practice to observe the operation for a short while before attempting to record any elapsed time readings. Then the elements of the operation are written down in advance in the order of their occurrence. If the same operation is done differently by different operators, the time-study sheets will show the actual methods of each operator. Later on, when a standard practice instruction card is being made out, the sequence of operations which is the most desirable may be adopted.

Advantages of the Four-Watch Board.—Another advantage, and perhaps the most important from the standpoint of saving the time-study man's time and increasing the observer's efficiency while making studies, is that when one watch is stopped at the elapsed time for an element the other watch is started automatically by the same movement. This watch that was stopped continues to register the time elapsed until it is snapped back, which need not be until after the entry has been made on the sheet. It may then be snapped back to zero where it will remain until the other watch is stopped when it will again start automatically to record the time elapsing for the next element.

The two watches on the right-hand side of the board both run continually, one registering hours and minutes and the other registering minutes and hundredths of a minute. In the illustration, the second hand on the day watch is shown making one revolution to each revolution of the decimal hand on the stop watch. The half-hour hand of the stop watch makes two revolutions for each revolution of the hour hand on the ordinary watch. After using this time-study board for some time, however, it was noted that the second hand on the day watch, and the half-hour hand on the stop watch were not needed and it was an improvement which simplified things somewhat to have them removed. Accordingly, the time study boards now in use by the writer have no second-hand on the day watch and no half-hour hand on the one stop watch.

These watches that run continually are used to record starting or finishing exact time of any complete cycle or operation, and are also useful to check up the individual cycles.

The watches running under tandem control make one complete revolution per minute and each minute is divided decimally into 100 parts. Each one-hundredth part of a minute is measured off, by three quick jumps of the decimal hand. When one watch is stopped and the other started, there is the possibility of an error equal to one of these small jumps or about one three-hundredth part of a minute. Therefore, if the recording watches are reversed quite a number of times, there might be a small loss when the total of times recorded are checked up with the difference between the time of starting and the time of finishing as shown by the two watches that run continuously. However, one of the greatest advantages of making time studies with this device is the possibility of obtaining time studies covering 60 full minutes for every hour of the observations. It will also be possible to check up the total time of all elements shown in any cycle against the actual time elapsed as shown by the readings from the day watch and decimal timer correct to the same part of a minute as recorded by the tandem stop watches.



PLANT No. 16 PLANNING DIVISION TIME STUDY DATE 6-8-1917
REPETITIVE CYCLES
OPERATION Punching 3 holes in mud guard No. P14X.
ELAPSED TIME OBSERVATIONS

1 Walking 4 steps to the parts supply pile	.05	.04	.07	.04	.06	.04	.04	.35	.05	
2 Stooping to floor	.04	.03	.04	.02	.02	.03	.03	.21	.03	
3 Lifting part & rising	.05	.04	.08	.04	.04	.03	.02	.28	.04	.04
4 Walking 4 steps to machine	.04	.04	.04	.07	.04	.06	.06	.35	.05	
5 Placing part against gauge	.06	.04	.03	.05	.02	.06	.08	.35	.05	.04
6 Punching 1st hole	.08	.08	.08	.08	.08	.08	.08	.56	.08	.08
7 Moving part to stop	.07	.09	.06	.08	.08	.07	.09	.56	.08	.08
8 Punching 2d hole	.08	.08	.08	.08	.08	.08	.08	.56	.08	.08
9 Moving part to stop	.09	.09	.07	.08	.07	.08	.08	.56	.08	.08
10 Punching 3d hole	.09	.09	.09	.08	.07	.07	.07	.56	.08	.08
11 Delivering part 3 steps to a wheelbarrow	.03	.03	.03	.03	.03	.03	.03	.21	.03	
12 Placing on pile evenly	.06	.05	.04	.04	.05	.05	.06	.35	.05	.06
13 Returning 3 steps to machine	.03	.03	.04	.03	.04	.06	.05	.28	.04	
14 Entering count on tally sheet	40	52	46	46	50	42	48	3 22	46	
Complete Cycles	1 18	1 25	1 21	1 19	1 18	1 18	1 23	8 42	1 20	.54
15 Time allowance for fatigue and unavoidable delays										.06
								Total —		.60
LEGEND—The average percent of the total average time required for each necessary motion is indicated graphically by cross hatching.										
SUMMARY										
Time considered necessary	= 50%									
" " possible to eliminate	= 50%									

REMARKS

Specimen Time Study Sheet.

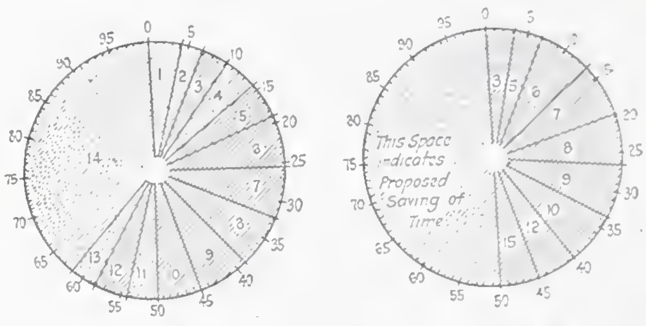


CHART SHOWING TIMES OF MOTIONS OF THE PRESENT AVERAGE CYCLE.

CHART SHOWING TIMES OF PROPOSED STANDARD CYCLE.

Graphic Illustration of Average and Proposed Cycle.

If any element of the operation or time has elapsed, which is not accounted for, it will immediately show up during the checking process. On the other hand, if the total time of elements observed checks up it will prove absolutely that the total times shown in the studies are true and correct.

Reading Continuously Running Watches.—To read the hour, minutes, and the hundredth parts of a minute accurately on watches that are running continuously, it is best to note the elapsed time recorded by reading from the decimal hand first, as follows: ".20 after 9:30." It should be written thus: "9:30.20." It is then possible at any later time that may be convenient to determine the amount of time elapsed between the starting and the finishing of the extra cycle or operation by deducting the time which had elapsed at the start from the time which had elapsed at the finish of the extra cycle or operation observed.

When making speed studies of machines or operations, it is desirable to know accurately what per cent of the total time of man or machine is spent "waiting," and what per cent is spent "working." From this may be estimated approximately the amount of time that is lost which might be applied to production. These may easily be obtained when using the improved device by adopting the plan of merely running one of the tandem watches to record "working" and the other to record "waiting."

No matter for whatever purposes time studies may be taken, they should show as separate elements all times or motions which may be finally combined or eliminated, and also all other information so arranged that the results are plain and convincing. The proper conclusions may then be drawn promptly.

Labor and Material Requirements for Painting Railway Sign Boards

Interesting information on labor and paint requirements for painting railroad signs is given by tests made at the paint shop of the Middle Division of Michigan Central R. R. For the sign bearing the inscription "Danger. No thoroughfare. People are forbidden to come upon the railroad premises," the material required was as follows:

¼ lb. white lead paint mixed for priming.
¼ lb. white lead paint for second coat.
⅛ lb. lamp black mixed.
3 oz. putty.
2 oz. shellac.

The sign was 18 in. x 37 in. inside dimensions and was stenciled on one side only.

The labor time on this sign was as follows:

	Minutes.
Shellacing knots	2
Priming	6
Puttying nail holes	2
Applying second coat	5
Stenciling:	
Fixing stencil on sign board	2
Preparing black paint	5
Daubbing stencil or stenciling letters	3
Finishing in letters	6
Painting board black	2
Setting up signs to dry	2

The labor time for signs of the same size as the above but lettered on both sides was as follows:

	Minutes.
Fixing stencil	1
Daubbing stencil or stenciling letters	7
One side filling in letters, per side	7
Daubbing letters or stenciling letters, second side	6
Finishing in letters, second side	6
Panting board black	5

The foreman's time on this work was 50 minutes at $95 per month. Labor lettering was paid at rate of 34 ct. per hour; labor for priming and second coat was at rate of 30 ct. per hour. White lead mixed cost 10½ ct. per pound; lamp black mixed cost 20 ct. per pound. We are indebted to A. M. Van Auken, Assistant Engineer, Monon Route, for the above information.

Cost of Digging Drainage Ditch with Dragline.—A gasoline driven ½ cu. yd. drag line during the past season excavated a drainage ditch for the Modesto Irrigation District of Stanislaus County, California, at a cost of 13 ct. per cubic yard. This figure comprises actual running expenses, including labor and material, but not interest or deprecation. The material excavated was 50 per cent sandy loam and 50 per cent clay hard pan. The ditch had a 6-ft. bottom, was 8 ft. deep, with slopes of 1½ to 1. It was approximately 2 miles in length. The crew included one operator at $200 per month; one oiler at $5 per day and one 2-horse team and driver at $7 per day. The quantity of earth moved per 12-hour shift amounted to approximately 400 cu. yd. We are indebted to P. F. Jones, Chief Engineer of the district, for the above information.

The Iron Rule vs. the Golden Rule

By ROBERT W. SHELMIRE.

A survey of any library will disclose many books on the science of management and the principles thereof, but how often are the science and its principles absolutely correct? Is there not a great deal of human opinion mixed up with these principles?

A principle, it should be understood, is an unchanging rule. One which is correct, reliable and if rightly applied no mistakes could be made. Such are the principles of geometry, algebra and arithmetic. Errors may be made, but knowing the principle, the figures can be revised and the correct solution always be obtained.

John D. Rockefeller says, "I believe that the application of right principles never fails to effect right relations." Upon analysis, this statement indicates that it is not a matter of belief but actual knowledge. Right relations come from the application of right principles. It never fails; but what are these principles?

In my investigations of this problem I have come to the conclusion that we have been trying to get to the top of the ladder at one jump rather than climbing it round by round. The Golden Rule in industry has been suggested many times by many people, but seldom applied. Why experiment with scientific formulae until this simple little rule, "Whatsoever ye would that men should do to you, do ye even so to them," is put into practice? If it was right 2,000 years ago it is surely right today. Why not give it a good trial?

The old method of management was by the Iron Rule. Let no one believe for a moment that this rule is now obsolete. Evidence of this fact exists all around us but there is, however, a changed atmosphere.

Straw-boss, foreman, manager have learned to be less arrogant. Capital and labor have both learned that neither have absolute power over the other. This change has been brought about not so much from any desire to do right but from fear of the consequences of doing wrong. There still exists in the minds of a large proportion of the people an inordinate greed, a selfish desire to have, to control, to dominate. This is the principle of the Iron Rule.

A contractor agrees to pay double time at night and the men refuse to work in the daytime. A clerk asks for a raise and his employer says, "You can quit if you are dissatisfied." The profiteer mulcts the public in every way possible. We claim to be a Christian nation, but is this Christian? Did Christ teach these things? Did he say, "Do others or they will do you?"

Now few of us like to be preached to but as a plain business proposition it can be proved that it pays to supplant the Iron Rule with the Golden Rule.

The cry today is greater production. How can we produce more with less men working shorter hours? Change the state of mind from one of selfishness to one of desire to "do unto others" and the problem would be solved immediately. This is quite impossible of instant achievement of course, but it is possible to make the beginning.

Provide the conditions which create an interested worker. Train him to do his work properly. Give him some responsibility. Pay him more than enough to live on. Bar all paternalistic welfare schemes. Eliminate so far as possible the uncertainty of work. Share the profits with him. Do these things and you will find it pays. It increases the morale which, after all, is the thing most desired. The worker must know that the employer is giving him a square deal and both need to get each other's viewpoint. Try the Golden Rule.

Engineers and Architects Co-operate for City Planning and Zoning.—Co-operative efforts are being made in Philadelphia between the architects, engineers and other allied professions and organizations for city planning and zoning. At a meeting last week the Philadelphia Planning Conference adopted an outline for a permanent organization, the purpose of which shall be "To provide means for co-operation between organizations interested in the physical development of the metropolitan area of Philadelphia." This organization is the outgrowth of a meeting held at the invitation of the Engineers' Club of Philadelphia when delegates from some 35 civic agencies and city departments and bureaus met on Oct. 10, 1919, to consider provisions of the new city charter wherein it is optional with the new administration to create commissions on city planning and zoning. D. Knickerbocher Boyd is chairman of the executive committee.

Selling Construction Service by Correspondence*

By CHARLES F. DINGMAN,

Engineer, Flynt Building & Construction Co.

Engineering and construction organizations can use the letter as a business getter to an extent that may surprise them. My experience has been that well-written letters can save thousands of dollars in traveling expenses each year, to say nothing of the time saved through the elimination of premature and unnecessary calls; and still bring in all the business that the organization can properly handle.

This does not mean that letters will bring in orders for buildings in the same way that they might for baby carriages, but we have demonstrated conclusively that the right kind of letters will so pave the way as to enable the salesman to get all preliminary details shaped up and enable them to talk actual business on the first call. We used to find it necessary to follow a prospect sometimes through three or four interviews before we began to get really "under the skin."

One hundred and seventy-three thousand dollars in a single contract from a single letter seems like a lot to claim, yet I have the word of a client that he chose our organization from several that were competing, for the reason that while we refrained from calling and taking up his time with long interviews, our letter told him about our service in such a manner as to show him that he would get the greatest satisfaction from his investment by dealing with us. This was by no means a competition of prices, for we received the contract on the basis of cost plus ten per cent.

What might be considered as our first step toward advertising was the writing of individual letters to prospective clients whose names were obtained from trade reports and other sources. They were of the ordinary conventional or frapped type, written from our own standpoint, and as may be expected, produced no more than the usual amount of business that comes from such letters. It was not until we had given study to this phase of salesmanship that we developed a letter that could be depended upon to produce favorable replies.

The principle underlying all these letters was that of an offer of service. We never mentioned selling the prospect anything until he had broached that subject himself. Of course, we never failed to tell of the expert service rendered by our various departments, but our primary appeal was simply an offer of service in any manner that would be helpful to the prospect, a promise to relieve him of all those bothersome details which some people believe to be inherent in building operations.

The remarkable success which attended the use of these semi-individual letters induced us to try the plan of circularizing a large list of industries which we thought would sooner or later be in need of more buildings, instead of waiting until we learned through trade reports that they actually contemplated such work.

Our first circulars were in the form of folders, each month of a different shape, but always with a return card.

These produced fairly satisfactory results, but, even though I understand that it is considered axiomatic in the advertising profession that we must make it easy for the prospect to reply, it was not until we adopted the plan of sending each month a short letter, printed in "typewriter" face type on an ordinary press and without any reply card, that we began to get inquiries which we are turning into business.

We use a selected list which consists of the managing heads of the manufactories in the industries to which we cater and in selected territory. We never send our advertising matter unless we have an individual name to address it to.

The gratifying feature of this is that business obtained thus is obtained through salesmanship and through the superior value of the service to be renderd. It is free from destructive price competition.

While we try to have our circulars neatly and attractively gotten up, printed on a fairly good grade of stock and properly illustrated, we realize that as models of the copy writer's art or as masterpieces of the layout man's craftsmanship they might not draw a single prize. But our study of the results obtained leads us to believe that the average factory owner or manager will pay more attention to a few short sentences of plain statement printed on a fairly plain lay-out than he will to a very artistic work that lacks the few plain statements. A circular full of useful information is frequently filed for reference. Often an inquiry comes in which we can tell was inspired by a circular several months old.

Since our proposition is addressed directly to the utilitarian sense, our advertising is dressed in clothes that are in harmony with its nature.

The inquiries which come to us through our advertising usually reach us before the prospective client's project has fully crystallized. This gives us a chance to afford the client the benefit of our experience and frequently enables him to plan a much more economical building than would otherwise be practicable. It also gives us the much desired opportunity to educate him to see the advantages he gains by engaging a construction organization on the same basis as he engages any other professional service.

In cases where a manufacturer, or other building owner, has had a loss through fire, we write immediately and offer the services of our engineering department to assist in adjusting the insurance or in any other way that will help to minimize the inconvenience and to get things going again. We do not stress the fact that we would like to get the contract to rebuild as much as we do our desire to be of assistance.

There was one case where I should have had the opportunity to say that letters did the whole thing, if I had waited another day. It happened that I was passing the office of a prospective client with whom I had been corresponding. I called. In response to my question, "Is there are reason why I can't take that contract for the service station back with me?" he replied: "No, I was going to write you to that effect tonight." So the letters had really sold the building for me. I had never called upon the client before.

Most of the campaigns conducted in behalf of engineering or construction organizations seem to follow rather too closely the procedure used in promoting a tangible commodity. This has been possible because the organization being exploited had some one feature of its service which it accentuated above everything else and the campaign hinged upon that. Most notable in that class are those campaigns which exploit standardized types or designs of buildings.

The campaign which I have described differed from these in that, on the one hand, it aimed to exploit service only, and, on the other hand, was evolved as it went along instead of being fully planned in the beginning. I realize that the more scientific way is to plan the entire campaign fully in advance, but this one started without any intentions of being a real advertising campaign and grew up to be one later.

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*From Printers Ink.

The Need for Railroad Expansion

It is a matter of general knowledge that the railroad problem is one of the most serious confronting the country today. Anyone using the railroads, either for travel or for shipping, is aware that the present railway facilities are far behind present requirements; and while the nearly two years' trial of government operation has been under the handicap of unusual war conditions, no opponent of government ownership and operation would claim that the lack of adequate facilities is due to government operation. It is nevertheless true that from the very nature of things, the period of government operation has not improved the conditions.

Mr. Samuel O. Dunn, in an editorial in the Railway Age, has made a rather careful analysis of the railway satistics and draws some conclusions which should be of interest in view of the pending railroad legislation in congress. Briefly summarized, his figures and conclusions are as follows:

In the 10 years from June 30, 1905, to June 30, 1915, the increase in the freight business was 61 per cent and the increase in the passenger business 45 per cent. Meantime, the investment made in new facilities was $5,300,000,000, or 44 per cent. The increase in freight business since the year ended June 30, 1915, has been 57 per cent, and the increase in passenger business 32 per cent, each being almost as great as it was in the preceding 10 years. If the new investment had been as great in proportion to the increase in traffic during the last four and a half years as it was during the preceding 10 years it would have been about $5,000,000,000. As a matter of fact, it has been less than $1,900,000,000. Furthermore, because of advances in wages and in prices of materials, a dollar would not buy during the last 4½ years more than two-thirds, and perhaps not more than one-half as much as it would buy on the average during the preceding 10 years. Therefore, equated on the 1905-1915 basis of the value of money, the investment during the last 4½ years has been only about $1,300,000,000.

Assuming that investment should have been made during this 4½ years as fast in proportion to the increase of traffic as it was during the preceding ten years, the investment in the railways has fallen behind approximately $3,700,000,000 during this time. But that is stating the deficiency in the prewar value of money. In the year 1919 two dollars will not buy a railroad any more labor, equipment and materials than a dollar would on the average in the years 1905-1915. The average wage of an employe is now 125 per cent higher than it was then. Now, the deficiency of investment must be made up in dollars of the present value. On that basis it would take over $7,000,000,000 to make up the deficiency in railroad investment which has been allowed to accrue since 1915.

Great Increase of Traffic—Little Increase of Facilities.—This deficiency in investment is strongly reflected in the remarkably small increase in facilities which has been made. During the ten years ending with 1915 the increase in the freight traffic of the country was 61 per cent and the increase in the number of freight cars in service was 36 per cent. During the last 4½ years the increase in the freight traffic of the country has been 57 per cent and the increase in the number of freight cars in service has been only about 5 per cent.

Between 1905 and 1915 the increase in passenger traffic in this country was 45 per cent and the increase in the number of passenger cars in service was 36 per cent. Since 1915 the increase in passenger business has been 32 per cent and there has been practically no increase in the number of passenger cars. The increase in the number of locomotives in the country in the 10 years from 1905 to 1915 was 30 per cent. In spite of the enormous increase of traffic since 1915 there has been practically no increase in the number of locomotives. The increase in the railroad mileage of the country between 1905 and 1915 was over 40,000 miles, or over 4,000 miles a year. There has been almost no increase in mileage at all in the last four years, the mileage torn up or abandoned being practically equal to that built. There has been a great increase in the efficiency with which railway facilities have been used in recent years—most of this increase having taken place under private management during 1916 and 1917—and therefore it undoubtedly would be an exaggeration to assume that there must be an investment of $7,000,000,000 to make good the deficiency which has accrued since 1915. But allow all that we dare for that increase of efficiency, and cut the estimated deficiency in half, and you will still have a deficiency to make good of $3,500,000,000.

With a deficiency of at least $3,500,000,000 to make good and an investment of at least $1,000,000,000 a year required to provide for the growth of business, it follows that the railways, if they are to provide for the needs of American commerce, must raise and invest at least $6,000,000,000 or $6,500,000,000 of new capital within the next 3 years, if they are to catch up with the needs of the country. This is a conservative estimate. They ought to acquire within that time, for example, about 800,000 freight cars, 20,000 locomotives and 10,000 passenger cars and to provide other facilities—new lines, tracks, sidings, yards, terminals, roundhouses, shops, and so on—in proportion.

It has become impossible for the railroads to handle all the traffic which is offered to them at any time when the country is producing to anywhere near the limit of its capacity. In the fall of 1917 the Railroads' War Board warned the government that even then it had become impossible to handle all the available freight and that if the essential war traffic was to be handled the so-called "non-essentials" would have to be excluded. In 1918, under government operation, in spite of the fact that the government had almost unlimited power and the advantage of $577,000,000 worth of additional facilities the railway companies had provided in 1917, it was able to increase the freight handled only 2 per cent, and it found it necessary constantly to embargo many kinds of commodities. Last spring, when the railways lost a large amount of war business, there was a temporary surplusage of cars, but as soon as the country began to produce again on a peace basis this surplusage disappeared and during recent months it has again been impossible to handle all the available freight.

It has been impossible to furnish sufficient cars to the coal mines and that has cut down the production of coal. It has been impossible to furnish enough cars for the movement of lumber and that has curtailed the production of lumber. It has been impossible to furnish enough cars for the movement of wheat and that has curtailed the movement of wheat. The various state, municipal and other governments have appropriated $633,000,000 to be spent during the next year in building new roads. Those roads can't be built simply because the railways can't handle the materials.

Railways Limiting Factor in Production.—People talk about the need for an increase in production. There is great need of an increase of production, but there cannot be any further substantial increase of production in this country until there has been a substantial increase in the facilities of transportation, because there can be no substantially increased production without increased transportation. Unless there is invested in new railroad facilities within the next 3 years at least $6,000,000,000 of new capital, it is a perfectly safe prediction that 3 years from now the railroads will still be unable to move all the commodities that country can produce; and regardless of the amount of new investment made in railroads meantime there will not be a year in the next three, unless there is a severe depression in general business, when the railroads, whether under government or private management, will be able to move all the traffic which the industries of the country can offer.

Many people seem to think that as soon as the railways are returned to private operation there will be a restoration of the good freight and passenger service which formerly was rendered. The good service formerly rendered will not be restored immediately or very soon after a return to private operation because the cars, locomotives, tracks and yards required to render it do not and will not exist. They can be provided only by a vast expenditure of new capital, and unless there is a vast expenditure of new capital they never will exist.

Having provided means of preventing abuses in financial management in future the public must also in its own interest in some way assure to those who make investments in railways that they will be given opportunity to derive a reasonable return from their investments.

Intensity of Pressure on Rails

A sub-committee of the American Railway Engineering Association has reported in Bulletin No. 218 on some experiments with rails to determine the intensity of pressures from rolling wheel loads. The rail specimens were prepared by drilling the head with very small holes, which were then reamed taper and fitted with measuring plugs, with the idea that any closure of the holes could be measured by the lesser penetration of the plugs. These holes were drilled at distances from the running surface which were expected to define the limits of the flow produced and depths were chosen of approximately ⅛ to ⅜ in., varying by 16ths. Other tapered holes were drilled from the under side of the head upward, nearly to the running surface.

When the test rail (M) thus prepared, was placed in the machine and reciprocated under a chilled wheel carrying an initial load of nominally 30,000 lb. closure of all holes began at once and gradually increased throughout the test. After 110,000 passes, the load was increased to nominally that of 35,000 lb. for 120,000 additional passes, with the effect of somewhat increasing the closing rate.

In a second test with the test rail A, when the initial load was but 15,000 lb., increasing by steps to 20,000 lb., 25,000 lb. and finally 30,000 lb., no measurable result was produced at the two lower loads, but slight results from the 25,000 lb. load and the final effect with the 30,000 lb. load was less than in the original test.

Measurement showed that in all tests the scleroscope hardness of the metal within the space covered by the wheel contacts had gradually increased; the indications were that the surface hardness produced by the rolling action had adapted the rail to finally carry with little deformation loads which, if applied initially, would have produced very considerable flow.

It is to be noted that the scleroscope hardness continued to increase during the service test; originally but 27 on the top surface of the head, it finally reached 42 at the end of the test. The original surface scleroscope hardness is lower than that observed across the sawed end of the rail, the probable reason being the surface decarbonization of the rail during the heating process. This general increase in the surface hardening probably explains the remarkable wearing qualities of many old rails which were surface hardened by comparatively light loads when first laid and as a result they subsequently carried heavy loads with impunity.

Subsequently, these two pieces of rail were placed in track carrying heavy loaded freight tonnage for two periods of two weeks each. A surprising increase in the rate of flow was immediately apparent as shown by the closure of all of the holes on the gage side, so that the method of measuring by tapered plugs could no longer be used.

The service experiment seems to indicate that with this section and composition of rail, the load of 25,000 lb. per car wheel should not be exceeded, but the committee is not prepared to accept this as a general conclusion. The intensity of pressure which a given spot on the head of a rail will stand is evidently influenced by the resistance of the metal surrounding that spot, a larger or differently shaped head may yield to a much less extent. Some of the New York Central experiments show that where the wheel and rail contour fit, the areas of contact with a given load are much increased and this by longer contact across the head. If but one wheel contour and but one rail contour existed and could be maintained, this would go far toward settling the question, but it must be remembered that with the existing diversity due to modifications of the original contour produced by service, this ideal condition is not likely to be reached. It is very certain that the practice of allowing wheel contours to depart widely from the original standard before renewal or returning is at the direct expense of severe punishment of any rail section that can be devised. Moderate pressure may be expected where rail and wheel conform, but where this is not the case, very severe kneading of the steel in the head of the rail may be expected.

The New York Central experiment referred to was based on very careful measurement of the area of contact between wheel and rail as measured on very thin copper sheets, with a locomotive and tender. The average pressures for all wheels in two tests were 82,150 lb. and 57,425 lb. per square inch, respectively, different locomotives and different rail being used in the two tests.

The committee freely admit that the scale of their experiments is too small to justify any sweeping conclusions. There is some question whether the presence of the drilled holes, constituting mechanical defects, has facilitated flow that would otherwise not have occurred. The general distortion of the head, not confined to the positions of the holes, indicates that the metal in the head was in a condition of general flow.

A short review of various proposed methods of treating rails so as to prevent flow in the head due to excessive loads is appended to the committee's report as follows:

Full length rail of both 100-lb. and 125-lb. P. S. section have been heat treated and subsequently placed in track under the heaviest loaded freight movement in comparison with untreated rail from the same heat. The rail remained in the track until some of the untreated rail had reached its limit of wear, at which time all of the treated and untreated rail of both sections was removed. In all cases the heat treated rail showed for this period a much lower rate of abrasion, but we do not consider the results conclusive because of the very small amount of rail and because the only safe comparison is to continue such a test until the same amount of metal has been abraded from the heads of all the rail under test; this for the reason that the rate of abrasion is not necessarily proportionally the same during the entire life of a rail.

It can be positively said that the intensity of pressure in this case was well within the capacity of the rail of both the 100-lb. and 125-lb. sections.

The heat treatment for this rail consisted of heating in a vertical furnace to 840° C.; quenching for 30 seconds in water at 25° C.; and annealing at 450° C. for two hours. The dipping was vertical.

It is fair to say that no mill is at present in shape to heat treat its product. To do so would entail considerable expense and change in plant. This process can therefore hardly be considered as an available one at the present time.

There has been offered a method of accelerated cooling of the head of the rail by blowing air or steam on the head alone, it being claimed that this produces a hardening of the steel and refinement of the grain in the head. While this process has been applied to some experimental rail, the committee has no data as to the effect of the treatment in increasing the resistance to pressure.

There is also the possibility of alloy steels, among which the manganese is best known, both in rail and in frogs and crossings. It cannot be said that any of these have passed beyond the experimental stage and we merely mention them as possibilities.

Finally, and most immediately available, is increase in the weight of section with widening of the head, thus safely allowing of some hardening and also distributing the wear over a wider section.

Report of Am. Elec. Ry. Ass'n. on Concrete Fence Posts

The Committee on Buildings and Structures of the American Electric Railway Association, at the October meeting in Atlantic City submitted a report on concrete posts and methods of casting for same. The conclusions arrived at after making some simple tests and after investigating the methods used by several railroad companies are abstracted from the report, as follows:

Based on investigations made by this sub-committee it would seem that in the manufacture and use of concrete posts the following conditions must be considered: Due to the price of reinforcing steel, cost of plant and manufacture, also the cost of transportation of the finished post to the point at which it is to be used, it cannot be expected that the first cost of the concrete post will compare favorably with that of a wooden post.

If a concrete post is properly built with sufficient amount of reinforcement and sufficiently rich mixture of concrete the post should give a life which would entirely justify its cost. As a parallel case concrete trolley poles which can be built for $14 or $15 first cost will give satisfaction comparable with a steel pole costing $45, but of course do not compare favorably in cost with a wooden pole which might be used instead, costing only $7.50.

Some of the concrete posts which have been built in large quantities, using only No. 6 steel wires for reinforcing the 4½ in. diameter top post, have not been satisfactory, although the cost has been low enough to compare very favorably with wooden posts. The reason for the failure of these posts in our judgment is a lack of sufficient reinforcement, the reinforcement is too close to the surface of the post and the concrete mixture does not contain a sufficiently rich mortar.

As the strength of the concrete depends entirely upon the strength of the mortar used therein the mortar also being weaker than the sand or pebbles forming the aggregate, in order to get the strongest possible concrete the mortar should be made as strong as possible without using too much cement and only enough mortar used to properly cover the aggregate so that it will not be necessary to apply a surface finish, which should never be done. Following this principle the mortar used in the manufacture of concrete posts should never exceed the proportion of 2 parts of sand to 1 part cement measured by volume, aggregate not to exceed 4 parts, preferably 2½ parts, small broken stone or pebbles not over ½ in. in size.

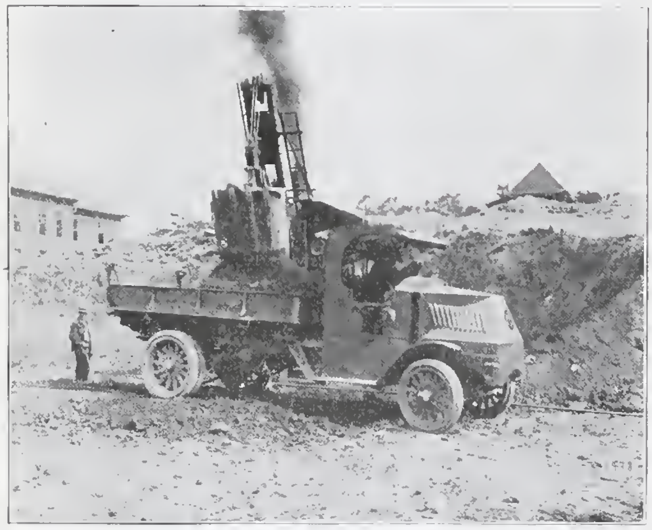
In the use of reinforcement we believe that a post should not be less than 5 in. in diameter at the ground line and the reinforcement should be placed approximately ½ in. from its outer surface to the outer surface of the post and should consist of at least four ¼-in. diameter steel reinforcing rods, with proper facilities for handling the posts at the plant and in the field a post 5 in. in diameter at the ground line would be a substantial size to adopt. Posts should be set not over 14 ft. centers.

Several patented machines for casting these posts which include metal forms which are left on the post while the same is getting the proper set are on the market. As far as our investigations extended these machines seem to be very practical for the purpose intended. At least 60 days should be given for the post to set in the yard before the same is placed in the ground. More time should be allowed if possible.

No attempt has been made in this report to give a drawing of the type of post above described inasmuch as the different companies would prefer to use different types of forms which would affect the shape of the post. We wish, however, to emphasize the point that in much of the present practice of building reinforced concrete fence posts an attempt has been made in the hope of securing a cheap post, to manufacture posts with too little reinforcement and too lean a concrete. If success is to be attained reinforcement and concrete along the lines specified above must be used.

Truck Backs Down 15% Grade to Dump Spoil

In disposing of the spoil from the grading of the new athletic field at the University of Tennessee, a 3½-ton Mack truck is backed down a 15 per cent grade so as to dump into a 30 ft. hollow which is to be filled. The grading involves the handling of over 50,000 cu. yd. of earth, which is being excavated with a steam shovel. Two routes are being used in getting the dirt to the place of disposal. One of these is a short cut down a 15 per cent grade that extends back about 600 ft., and the other is a longer route over very bad road to the other side of the hollow where the slope is more gradual. On the longer route 14 1¼-ton capacity wagons each drawn by 3 mules, and two light trucks are being used. The 3½-ton truck is used on the short cut, and although forced to back down the entire grade, is making 34 trips a day. The contractors for the graoing are the Dempster Construction Co., Knoxville, Tenn.



Loading 3½-Ton Truck With Steam Shovel.

Twelve Thousand Grade Crossings in Pennsylvania.—The Bureaus of Engineering and of Accidents of the Public Service Commission of Pennsylvania, which have been making a survey of the grade crossing problem, have found 12,000 grade rrossings of steam railroads in Pennsylvania, and in a report say the majority of them are without protection.

Cleveland Engineers Get Raise in Salaries.—Following a recent hearing granted to the engineer employes of the city of Cleveland before the Board of Control of that city, the latter body authorized an increase of 10 per cent in salaries of professional engineers employed by the city.

News Letter

St. Louis Items

S. Hanephin, R. No. 2, Jonesboro, Ill., was awarded contract for building the Cedar Creek drainage levee near Ware Station, Ill. Hanephin will sublet 75,000 yards of this at a good price.

Walter Dennison has 55 of his teams at work on a levee at Newport, Ark., and 40 teams on a levee near Cyppeel, Ark.; also was awarded contract the other day for 77 miles of State road work in north Arkansas between Batesville and Mamouth Spring.

Ira J. Printy has moved his team outfit on to General Motors Co. job in the western part of the city.

Cameron, Joyce & Co. were awarded four miles of concrete work on the State Highway near Greenville, Ill.

C. A. Samuelson was in town hunting up work for Mrs. J. McInerney's outfit which is idle in Indianapolis. 642 Congress St., Indianapolis, Ind., will catch her.

Keating Bros. are filling a trestle for the Chicago & Illinois Midland R. R.

Z. C. Mitchell of the L. J. Smith Const. Co., shipped another steamshovel, that they had stored here, on to their job on the White River branch of the Missouri Pacific R. R., in northwest Arkansas.

Costello Bros., Mike and Rich, were in a couple of times since last issue. Their outfits are at work on the Southern R. R. in Tennessee.

Ralph Thomas, representing the C. R. Cummins Co., of Cleveland, Ohio, is scouting around hunting up new jobs Was with us a day last week.

Mulvill Bros. are repairing a dam for the Chicago & Alton R. R. at Bowling Green, Mo.

Mark Ragsdale, of the A. V. Fetter Co., states they are going to place their steamer, Gardie Eastman, in the towing business down south during the winter.

The Leonard Const. Co., of Chicago, is enlarging the Corn Products Co. plant at Pekin, Ill. Have leased one of M. L. Windham's shovel outfits.

Columbus S. Jones, the boss stationman, secured some nice bank widening work in Oklahoma the other day.

Wickham Bros., Council Bluffs, Ia., were awarded some extensive road building, tile laying and grading contracts Expect to begin work about March 15th.

Contractor when in want of labor or work for their outfits write Koenig's Labor Agency, 612 Walnut St., St. Louis, Mo.; 503 Delaware St., Kansas City, Mo., or 509 S. 13th St., Omaha, Neb.

The Southern Traction Co., an uncompleted line extending from East St. Louis to Belleville and beyond that town into rich coal-producing territory of Illinois, was purchased on Dec. 11th, by C. B. Fox, general manager of the Aluminum Ore Co., and president of the Alton & Southern R. R.

A. B. Koenig.

Personals

Joseph K. Pettingill and George D. Remer have been appointed assistant engineers to the Michigan Public Utilities Commission.

Harry L. Shaner, formerly city engineer of Lynchburg, Va., has been elected Commissioner of Public Works of Winston-Salem, N. C.

Edward B. Temple, assistant chief engineer of the Pennsylvania R. R., has been appointed a member of the State Aid Commission of Pennsylvania.

J. C. Ragsdale, superintendent of the city water works and electric light plant at Alexandria, La., has resigned and is succeeded by John R. Langley.

Roy Ferguson of Visalia, Cal., assistant engineer of the State Railroad Commission of California, has been appointed to an engineering post with the new Polish government and will have charge of oil exploration and development work in Poland.

W. B. Storey, federal manager of the Atchison, Topeka & Santa Fe Ry., has been elected president to succeed E. P. Ripley, resigned. Mr. Storey was graduated from the University of California in 1881 and immediately entered the railroad business with the Southern Pacific, becoming assistant engineer the following year. In 1893 he accepted a position as assistant engineer for the U. S. Debris Commission, holding that post until 1895, when he became chief engineer and general superintendent of the San Francisco & San Joaquin Valley Ry. Between 1900 and 1906 he was chief engineer of the Atchison, Topeka & Santa Fe R. R., and in 1906 became chief engineer of that system, holding that position until 1909, when he became vice-president.

Obituaries

Dan Mrphy, foreman of bridges and buildings for the Frisco Ry., died Dec. 6 in St. Louis, Mo.

Henry Nelch, senior member of Nelch & Son, contractors, Springfield, Ill., died Dec. 6 of paralysis. He was 67 years old.

Henry Laurence Gantt, an authority on shop management, former student and instructor at McDonogh School and a graduate of Johns Hopkins University, died last month at his home in Montclair, N. J., of heart disease following an attack of indigestion.

Cornelius Kennedy, veteran street paving contractor, died Dec. 7 at his home in Parkersburg, W. Va. Mr. Kennedy entered the paving business in the early eighties and constructed the first brick street paving in many cities in West Virginia, Ohio and western Maryland. He took an active part in construction work up until a few months before his death, being the senior member of C. Kennedy & Son, street and road builders. Recently Mr. Kennedy disposed of his interests to the Kennedy Construction Co., of which his son John R. Kennedy, who has been associated with him since his boyhood, is president and general manager. This firm holds extensive contracts in West Virginia at the present time. Mr. Kennedy was 83 years old.

Frederick P. Stearns, a well known consulting engineer, former president of the American Society of Civil Engineers, died Dec. 1 in Boston, Mass., aged 63 years. He came to Boston at the age of 18 and entered the employ of the city engineering department. He was engaged in securing a water supply from the Sudbury River and later, as chief engineer, supervised the construction of a tunnel under Dorchester Bay and of the reservoir on Moon Island. In 1886 Mr. Stearns was made chief engineer of the Massachusetts State Board of Health, remaining until 1895. From that year until 1907 he was chief engineer of the Massachusetts Metropolitan Water Works. He served as consulting engineer for the Charles River Basin Commission from 1903 to 1910, and became a member of the Board of Water Supply for New York in 1905. He was a member of the Board of Consulting Engineers of the Panama Canal.

Industrial Notes

The Blaw-Knox Co. held its annual sales convention in Pittsburgh, Dec. 3-6. About 300 Blaw-Knox salesmen, engineers and representatives attended.

The Link-Belt Co. is making an addition to its Belmont foundry at Indianapolis, Ind. The extension virtually consists in completing the new furnace buildings, Nos. 7 and 8, but for the present installing only furnace No. 7, which will be a 15-ton capacity instead of 10-ton, like the present furnaces. Necessary machinery, such as rolling mills, sand blast and other foundry equipment needed to take care of the additional capacity, is being purchased. The building wil be about 70 ft. wide by 400 ft. long. When completed it will complete the foundry as originally laid out.

Building and Structural Monthly Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $3.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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"Home Rule" as the Precursor to Municipal Ownership

"Home rule" is a political slogan that is often used as if it were an axiom of complete generality. Changed from the slogan form to the axiom form it becomes: Local government is self-evidently preferable to any other form of political control.

In this form the doctrine of "home rule" appears more vulnerable than its advocates wish it to appear, so they are accustomed to avoid the alleged axiom and adhere to the slogan.

"Home rule" means "local government." "Local" is a relative term. City government is "local" as compared with country government. Country government is local compared with state government. State government is "local" compared with national government. If it were true that local government is universally preferable to government that is not local, it would follow that the "more local" the government the better. This would lead in all cases to ward government in preference to city government, city in preference to county, county in preference to state, state in preference to national government. If so, the ward should be the political unit in control of streets, sewers, police department, etc. The absurdity of such an extreme of local government is apparent, and it serves to illuminate the absurdity of regarding "home rule" as being universally desirable.

Many politicians and even some editors of high grade daily papers favor the regulation of street car and other utility rates by city councils or city commissions, and they hold this preference not because experience demonstrates such "home rule" to be desirable, but merely because it is "home rule." Illustrative of this we quote the following from a recent issue of the Chicago Daily News:

> It is, of course, humiliating to the people of Chicago to be compelled to rely upon a state commission to tell them what fare they must pay on the street cars operating on Chicago streets by virtue of franchises granted by the city. Now the citizens have been given a little time in advance of the constitutional convention, for one more striking object lesson in the need of home rule in their relations with their local public utilities. A city commission or board would scarcely have fallen into the errors which the state body, responsible only to the state executive, and too busy carefully to study complex and mixed local situations, plainly has been betrayed. Further, a decision by a state commission in the nature of things cannot have the moral weight and sanction that a decision by a competent local body under a home rule charter would command.

The Chicago Daily News sees in the failure of the city authorities to secure a return to the old 5 ct. fare an

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

evidence that the good old principle of home rule has been violated with dire consequences. It finds humiliation in being compelled to bow to the decision of a tribunal that is not local, merely because it is not local. And being humiliated and outraged, it is only natural that it first sees red, and then talks red, for it accuses the Illinois Public Utilities Commission of being "too busy to carefully study complex and mixed local situations"! This accusation is made in the face of the fact that the Illinois Public Service Commission has spent more time gathering and analyzing all the facts relative to the Chicago street railways than all the city councils and mayors have spent during the entire history of Chicago.

If the Chicago Daily News wants municipal ownership of street railways, it can do nothing that will aid more to bring this about than it is doing when it speaks disparagingly of the state public utilities commission.

Every one who has studied rate regulation knows that the main defect in our present system is the fear on the part of rate commissioners that they will lose their jobs if they do not please the public that pays the rates. City councils and city rate commissioners are usually cowardly to such an extreme that it is almost impossible to get a fair rate decision from them. State commissioners are much less cowardly, but even they are not always entirely uninfluenced by the effect that their decisions will have upon the voters. It is generally agreed that the fairest rate decisions are usually rendered by the federal courts, because the federal judges are not afraid of losing their jobs if they fail to please the public.

The public, be it remembered, is pleased in proportion as the rates are lowered. This is so well known to politicians that the platform of many a would-be city mayor consists mainly of one plank: "I favor lower rates for public utility service." At this moment Mayor Thompson of Chicago is standing on such a platform, and loudly denouncing the Illinois Public Service Commission for not giving the citizens a 5 ct. car fare.

The public is ignorant of the facts but is prone to follow any leader who denounces public utility corporations and promises a reduction in their rates. If the Chicago Daily News aims to crowd all the utilities in Chicago into the hands of the politicians, let it join Mayor Thompson in demanding "home rule."

Political Engineering

If engineering is applied science, and if science can be applied to political affairs, then it should not be incongruous to speak of political engineering. The term does sound incongruous, we must admit, but why? Simply because typical politics is almost void of science.

Thorough gathering of data, followed by careful classification and systematic analysis, are three processes that distinguish scientific from unscientific methods. Apply this criterion to the actions of the average legislator if you wish to understand why it is that the transactions of congresses and city councils are so frequently futile or positively harmful. Herbert Spencer, after listening for many days to a debate in the House of Commons, ending in the passage of an important bill, remarked that he believed that the House would do better in future to select its most stupid member and let him formulate the bills, provided only he were required to spend in study as many hours as would ordinarily be spent in debate.

Nearly everyone who has followed the procedure of our own national and state legislators and city councilmen is satisfied that our legislative bodies are unscientific in their methods, cumbersome and slow in their actions, and seldom correct in their conclusions. This is generally admitted, but there the matter ends. The machine is obsolete, but no serious attempt is made to scrap it and substitute one that is up to date.

It is our belief that the engineers of this country can and will be the prime movers in effecting a radical change in governmental management. They are the only large body of men trained to apply science in the solution of economic problems. The problems of political government are, in most respects, identical with the problems that engineers are accustomed to solve. Even where they differ in detail the principles to be applied are the same.

The Engineering Council of the "founder societies" has a committee on public affairs. Every local engineering society, be it an independent organization or a chapter of a national association, should have a similar committee composed of engineers who have both the inclination and the ability to teach the public the necessity of employing men who are political engineers in the true sense of the word engineer.

The Public Is a Poor Employer

The public is a poor employer. Perhaps a sudden and great rise in the general level of wages and prices was needed to drive deep the truth of this generalization. Hundreds of army and navy officers have resigned during the past few months because their salaries were grossly inadequate. Thousands of public school teachers have resigned for the same reason. Engineers in the employ of cities, counties and states have given up their jobs by the hundreds, and will soon leave in greater numbers unless salaries are raised. Postal clerks and mail carriers go about in old shiny clothes or new "shoddy." Policemen join unions and even strike. All this because the public is not a liberal or even a fair employer.

The public wants low taxes, and easily loses its patience with any administration that raises taxes, be the reason what it may. So the politicians play the game of keeping taxes down wherever they can not personally profit by keeping them up.

On the other hand, let a large labor union threaten these same politicians with loss of their jobs unless union wages are raised, and you will usually see wages raised regardless of taxes. This is what happened in the railway field.

Under our present form of government, the income of any class of public employes is largely dependent upon the number of votes they can control, as measured against the number of taxpayers who will be disgruntled if taxes are raised. Not a very economic system of wage regulation is it? Yet many a civil engineer has favored government ownership of railways and other public utilities. To all such we suggest thinking the matter over a bit, in the light of present difficulty in getting the public to pay salaries proportionate to the real value of services.

Advertise Engineering

A pamphlet recently issued by the American Library Association states that "Probably 70 per cent of the entire population of the country has no access to any adequate collection of books or to a public reading room." This is bad, but what is much worse is that of the 20 per cent that do have access to adequate libraries probably not 5 per cent avail themselves regularly of their opportunities.

In spite of the fact that illiteracy is relatively rare in America, and that nearly all our people have presumably been taught the value of knowledge and how to acquire it, we are not a knowledge seeking people. The reason that we are not is plainly to be found in our defective methods of education.

As we conceive it, every educator should have three primary objects: First, the arousing of interest in the subject at hand. Second, habituating the students to search for, analyze and use information. Third, training the student to think. This third object has been given a good deal of discussion in recent years, but the second object has almost been lost sight of, and the first object has fared little better. In short, the psychology of teaching has been almost ignored. The result is that relatively few people have a thirst for knowledge, and fewer have acquired habits of studying and using printed information.

Although the percentage of college graduates who have acquired studious habits is undoubtedly larger than of those who have never attended college, still the colleges have failed to make the average college man habitually studious; nor do we except engineering colleges from this charge.

Although new habits are formed with greater difficulty the older a person is, still few men are too old to acquire a new habit, provided they are properly "coached." Acquiring a new habit by self training is very difficult. Hence the desirability of working under a teacher or trainer even where the habit might possibly be acquired without guidance.

To most engineers the habit of systematic and thorough searching for information is new. In other words, most engineers do not possess that habit. Their failures to make satisfactory progress are mainly attributable to this deficiency. Even where the question is merely one of securing better income, there is a problem to be solved, and there are data to be searched for if it is to be solved satisfactorily. But how many ill paid engineers regard their small remuneration as evidence that they have not studied the science and art of salesmanship? Do they not ordinarily blame their employers instead of blaming themselves?

We suggest that engineering societies form classes to acquire the habit of searching for information. Let each of the local chapters appoint, from among their members, mental trainers who will drill the members in searching for data on subjects in which they are, or should be, interested. Start, for example, with advertising and salesmanship. There are scores of books and magazines on the subject, and it is a subject that should concern every man who has services to sell. That engineering services sell, as a rule, for a low price is not due to the great supply of engineers, for there is only one engineer per thousand of population. The price is low because the demand is weak, and the demand is weak because engineering has never been properly advertised and marketed. That it has not been advertised is clearly the result of ignorance on the part of engineers, and the ignorance, in turn, exists only because engineers are not habituated to study all their problems systematically and thoroughly. So we come back finally to our starting point—the general absence of studious habits.

Should Architects Advertise?

The publication of a page advertisement of architects specializing in school work in the leading school publication is interesting and significant of the changing attitude of members of this profession toward advertising, states The Architect and Engineer. While for many years the ban has been placed on the use of advertisements by architects for the purpose of getting clients, the fact that architects as a body have resorted to business promotion methods along other lines has helped to demonstrate the inconsistency of the ruling regarding advertising in publications.

The architect is permitted to solicit commissions directly in person, and to use letters for this purpose. If he may seek clients in this fashion, why should he not offer his services through the medium of a dignified advertisement, especially when this is directed to a particular group of people, to whom he is in a position to render a valuable specialized service?

There is no analogy between the medical man and the architect, and the fact that doctors do not advertise does not represent an argument against architects advertising. Doctors are not permitted to solicit cases either directly or indirectly, and the freedom with which architects are permitted to present their claims to consideration puts them in a different class from that occupied by the physicians.

The tendency toward specialization on the part of architects, which has been marked of recent years, makes these professional men more interested than heretofore in cultivating those in the fields with which their work is principally connected. Class, trade and technical papers in those fields are logical mediums by means of which to make their announcements and get in touch with those desiring specialized architectural service.

November Building Operations.—Building contracts awarded during the month of November, 1919, in the territory north of the Ohio and east of the Missouri rivers, amounted to $221,450,000, according to statistics compiled by the F. W. Dodge Co. This figure, although 29 per cent less than the figure for the month of October, was somewhat in excess of the average of the monthly figures for the first 10 months of the year. Of the total amount for October, 32 per cent, or $71,267,000 was for residential buildings; 31 per cent, or $70,222,000, for industrial buildings; 15 per cent, or $33,878,000 for business buildings; and 10 per cent, or $21,451,000 for public works and utilities. The November figures brought the total for contracts awarded for the first 11 months of 1919 up to $2,332,902,000. The total for the first 11 months of 1918 amounted to $1,631,929,000, 33 per cent of which was for government work. Even though the increase of construction costs be taken into account, the figures indicate a total volume of construction in the first 11 months of 1919 somewhat in excess of the average annual volume of the 5 years previous to 1919.

"Notes on Indeterminate Structures"

To the Editor: The article by Mr. George Paaswell on "Some Notes on Indeterminate Structures" in your issue of Sept. 24, 1919, and the discussion by Mr. M. Grodsky in the issue of Nov. 26, 1919, bring to notice a very interesting sort of problem, and the writer regrets that the discussion apparently did not settle the difference of opinion as to the correct analysis of this rather simple frame.

The problem is the determination of the bending moments and reactions for the frame shown in Fig. 1a. As was pointed out in the discussion, Mr. Paaswell's calculations were based upon one false premise, namely, that with the thrust H in the proper direction as shown in Fig. 1b.

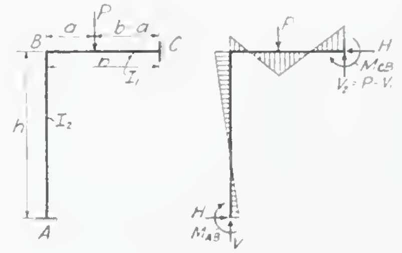
$$V_1 = Hh/b + P(b\text{-}a)/b \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

This equation is supposed to be derived by writing equations for the equilibrium of the body as a whole. Taking moments about A and C, respectively, gives

$$\Sigma M = O = M_{AB} + M_{CB} + Pa - Hh - (P - V_1)\,b$$

$$\Sigma M = O = M_{AB} + M_{CB} - P(b\text{-}a) - Hh + V_1\,b$$

These two equations are identical and will not yield Equation 1 unless M_{AB} is equal to M_{CB}, which can never be true with this type of loading. That Equation 1 does not hold true is not strange since this structure is in reality a no-hinged arch, a three-fold statically indeterminate structure. The third statically indeterminate quantity such as V_1 or M_{CB} must be chosen, and the partial derivative of the internal work with respect to this quantity set equal to zero, as was done by Mr. Grodsky.



(a) (b.)

Fig 1

Another method of analysis may serve to check the final working equations which were derived. By the use of the Slope-Deflection Method* it is known that for Fig. 1a, letting $n = I_1 h/I_2 b$, and $K = I_2/h$

$$M_{AB} = 2EK\theta \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$M_{BA} = 4EK\theta = 2M_{AB} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$M_{BC} = 4nEK\theta - C_{BC} \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$M_{CB} = 2nEK\theta + C_{CB} = M_{BC}/2 + C_{BC}/2 + C_{CB} \ldots\ldots (5)$$

in which equations θ is the slope of the elastic curve at the point A, and C_{BC} and C_{CB} are the moments which would occur at B and C if BC were a "fixed" beam.

From Equations 3 and 4, assuming that E is constant,

$$M_{BC} = -M_{BA} = -2M_{AB} = -\left(\frac{C_{BC}}{n+1}\right) = -C_{BC}\left(\frac{I_2 b}{I_2 b + I_1 h}\right)$$

From Equations 4 and 5.

$$M_{CB} = \frac{nC_{BC}}{2(n+1)} + C_{CB}$$

Knowing these moments the reactions may be found from the equations of statical equilibrium. For example, since from equations 2 and 3 the point of contraflexure in AB is at a height of h/3, the horizontal thrust is

$$H = 3M_{BA}/2h$$

and by taking moments about the point C it is found that

$$V_1 = P\,(b\text{-}a) - (M_{BC} + M_{CB})$$

Values of C_{BC} and C_{CB} for a single concentrated load P on BC are $\frac{Pa(b\text{-}a)^2}{b^2}$ and $\frac{Pa^2(b\text{-}a)}{b^2}$, respectively; for a triangular load w increasing from B to C they are Wb/15 and Wb/10, while for a uniform load W they are both equal to Wb/12. As noted by Mr. Paaswell, values of moments due to a vertical load on BC may be adapted to apply to the case of a horizontal load on AB by interchanging the notation, so that for the cases of loading noted in the original article the expressions for the moments given in Table 1 may be found. It will be noted that the values given under the first case of loading agree with those derived in Mr. Grodsky's discussion.

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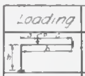
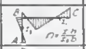
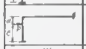
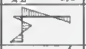
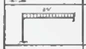
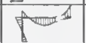
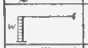
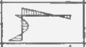
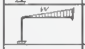
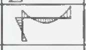
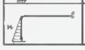
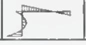
*See Bulletin 108, Engineering Experiment Station, University of Illinois, Urbana, Ill., entitled "Analysis of Statically Indeterminate Structures by the Slope-Deflection Method," by W. M. Wilson, F. E. Richart and C. Weiss.

Table 1. Bending Moments in the Frame of Fig 1.

Loading	Moments	Value of M_{AB}	Value of M_{BC}	Value of M_{CB}
		$+\frac{Pac^2}{2b^2[n+1]}$	$-\frac{Pac^2}{b^2[n+1]}$	$+\frac{Pac}{2b^2}\left[\frac{cn}{n+1}+2a\right]$
		$-\frac{Pde}{2h^2}\left[\frac{e}{n+1}+2d\right]$	$-\frac{Pnde^2}{h^2[n+1]}$	$-\frac{Pnde^2}{2h^2[n+1]}$
		$+\frac{Wb}{24[n+1]}$	$-\frac{Wb}{12[n+1]}$	$+\frac{Wb}{24}\left[\frac{3n+2}{n+1}\right]$
		$-\frac{Wh}{24}\left[\frac{2n+3}{n+1}\right]$	$-\frac{Wnh}{12(n+1)}$	$-\frac{Wnh}{24[n+1]}$
		$+\frac{Wb}{30[n+1]}$	$-\frac{Wb}{15[n+1]}$	$+\frac{Wb}{30}\left[\frac{4n+3}{n+1}\right]$
		$-\frac{Wh}{30}\left[\frac{3n+4}{n+1}\right]$	$-\frac{Wnh}{15[n+1]}$	$-\frac{Wnh}{30[n+1]}$

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Urbana, Ill.

Unionism and the Engineer

To the Editor: In your issue of Nov. 26th, p. 612, appears an article headed "Position of the A. A. E. on Trade Unionism in the Profession." It is of course the recognized appeal of the "professional" engineer to the younger generation to uphold the "dignity" of the profession. The thousands of technical men who have already chosen unionism as the most available vehicle for their material advancement, and other thousands who are almost persuaded, have no quarrel with professionalism per se. They believe that the great body of employed engineers and draftsmen are technical men and often of the highest type, but that, in general, so long as they remain employed, they cannot be called "professional" in a true sense. (We refer to a definition of "professional man" set forth by the present president of the A. A E.) Many of them will become professional men, and properly, but most of them will continue to be paid by the day or the week or the month to apply in a limited space the tabulated results of engineering science.

But even were these men wrong in this belief, there is in this "credo" of the A. A. E., no indication of a convincing argument against the adoption of union principles by technical men for their material welfare. There are, however, numerous statements apparently considered to be axiomatic, which seem to us to be fairly wide open for discussion. We read, "Production should be increased, not limited. . . . The law of supply and demand for men or material must ultimately prevail. Attempts may be made to limit the supply of either, but . . . we believe rather in increasing the demand through the promotion of legitimate enterprise."

Is it not a part of the function of the law of supply and demand to react upon production so as to limit an over supply or to prevent the bottom falling out of prices? If so, then the first statement is only partly true, and needs further specification.

Again, we may admit the ultimate triumph of the law of supply and demand, but we are not ultimate, we are proximate —very much so, and merely to believe in increasing the demand through promotion of legitimate enterprise is to substitute further trust in the future for a much needed and too long delayed relief. Moreover, this matter of supply and demand is not as simple as it sounds. Demand for engineering service is a legitimate demand by "capital" or "enterprise," for labor. The supply of engineering service may be individual so that it may be immediately applied on the demand, as are the doctor's services in the case of human suffering or those of the attorney when some one is enmeshed in the toils of the law. Usually, however, an engineering demand creates a secondary demand for other technical men, that is, for the raw material of engineering service; and here as elsewhere there is the middleman, namely, the engineering firm, or the engineering department of the large corporation, whose natural interest it has always been to supply the demand of enterprise at as low a cost as possible for raw material, viz., designers, draftsmen, tracers, rodmen, instrument men, inspectors, assistant engineers. Now middlemen or brokers, in other lines are constantly under the suspicion of acting on this natural tendency to "buy low and sell high," and to control by various means, both the buying price and the selling price of a commodity. Is it then strange if these employing engineers fall under the same suspicion (and they have of late frequently confessed their past sins in this regard) at least so far as "buying low" is concerned, even though it be only for the purpose of making efficiency records?

If unions, too, have learned to make use of such methods, are they any more than observant pupils? And if thousands of technical men have found the engineering societies to be controlled largely by this "middleman" type of engineers, are they to be blamed if they turn to some other form of organization to get results?

Also, it occurs to some of us to ask—if the laws of supply and demand have been operating and ought to continue operating, wherefore should the A. A. E. or the unions either, attempt to interfere in any way with the process? Of if they have failed to operate, does the program of the A. A. E. offer any assurance for the employed technical man as to the future?

As to the rewards of "ability, initiative and constructive effort," we can subscribe as heartily as the A. A. E. to the necessity and justice of that; but knowing how few those rewards can be, shall we not object to the continuance of methods by which the 90 per cent or more of the good average pluggers are lulled to sleep by pretty promises while the 10 per cent or less receive rewards large enough to keep the promises bright?

We, also, can deprecate heartily, "any methods that may benefit a class at the expense of the nation as a whole." The outstanding fact, however, is that engineers as a class have but just begun to share equitably in the benefits which decades of material prosperity have brought to the nation but mostly to the promoters of "legitimate enterprise."

This condition in the early years of our prosperity forced and fostered the growth of unionism, but does that mean that its measurable successes are evidence of an avowed purpose to better a class at the expense of the whole nation? Rather a defensive determination that since some classes have not benefited in proportion to their services they shall benefit as they should.

We read further, "The aim of the profession is to advance civilization and to render the highest service to humanity. Except when their acts further this aim, it is an advocate of neither capital nor labor." This is a purely negative statement. It must normally advocate both. And when there is disagreement and unrest is general, how shall neutrality be maintained?

If the A. A. E. be governed by this "professional" creed, will not the small and distinctly professional group apply the principles and direct the attitude of the organization? Will not the close relations of that group to so-called capital lead them of necessity to the side of capital in a controversy? Wherein then can the average technical man satisfy himself that the interests of the 90 per cent are being cared for except as they meet with the pleasure of capital?

Such questions as these are bound to arise in the mind of the employed man whose economic status is that of labor regardless of his desires or of his final goal.

COMMITTEE ON PUBLICITY,
Local 14, Chicago, of Technical Engineers, Architects and Draftsmen Union.

Razing Brick School Building with Dynamite.—A brick school building at Ozark, Ala., damaged by fire so that only the outside walls and partitions remained, was razed with dynamite. The structure was 60 x 80 ft. in plan, and 40 ft. high, with walls 20 in. thick. At a point 3 ft. above the ground, holes were drilled in the brick wall about 14 in. deep and large enough to allow the placing of the 40 per cent ammonia dynamite cartridges with detonator inserted. The charges were confined with a proper amount of clay and mortar. Four shots were fired simultaneously and this performance was repeated four times to completely raze the walls. The explosions toppled over the walls and piled the bricks in a somewhat orderly fashion so that their salvaging was accomplished economically and in such quantities as to materially decrease the number required when the new building was erected.

The New 260 Ft. Span Single Leaf Bascule Bridge of the Illinois Central R. R.

The largest single leaf bascule bridge yet constructed will be placed in service early next month, over the South Branch of the Chicago River at 16th St., Chicago, on the St. Charles Air Line. The St. Charles Air Line is a short section of railroad operated by the Illinois Central R. R. and owned jointly by it and the following railroad companies: The Chicago, Burlington & Quincy, the Chicago & Northwestern, and the Michigan Central. It runs in an easterly and westerly direction near 16th St. and connects the terminals on the lake front with the various railroads using the terminals in the vicinity of the river and though short in length is nevertheless an important factor in railroad operation in Chicago. The river was formerly crossed near 16th St. by means of a double track horizontally swinging draw bridge 297 ft. 6 in. long, (See Fig. 1) at an angle of 42° 43′ providing two channels 59 ft. clear in the East, or main channel, and 55 ft. in the west channel for navigation at right angles to the channel. The alignment and track arrangement were changed to accomodate the new double track bridge which crosses the river at an angle of 63° 28′ being 260 ft. long between end bearings of the moving leaf and providing a clear channel for navigation 200 ft. wide at right angles to the channel. It should be noted that the location adopted for the new bridge was very nearly fixed by the track arrangement on the east side of the structure. By locating it as far north as possible traffic was not interrupted and the span length was decreased. The south wye, however, on the east side of the river fixed the most northerly location which was the one finally adopted.

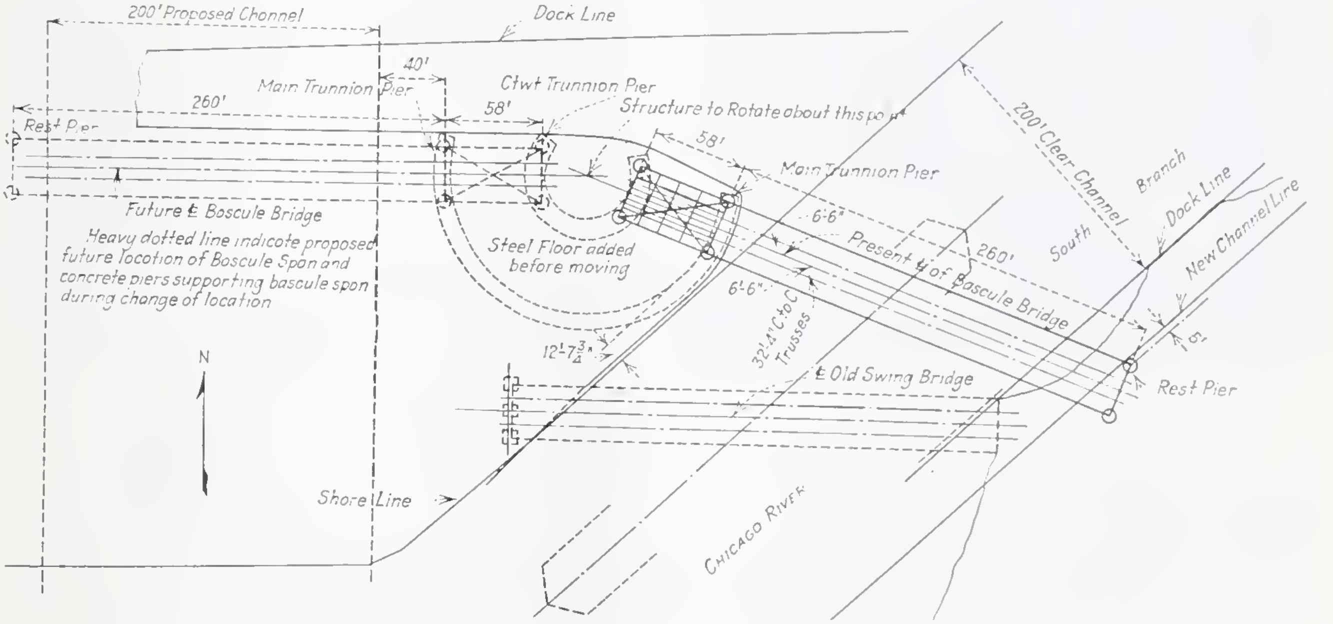


Fig. 1—Present Location and Proposed Future Location of Bascule Bridge.

Figure 2 is a general plan and elevation of the new bridge including the short concrete trestle approaches, showing substructure and superstructure, and will readily be recognized as the Strauss heel trunnion type of bascule bridge.

The bridge is supported by cylinder piers extending down to rock, pier I being the rest pier supporting the front, or, free end, of the bascule span; pier II supporting the trunnion, or pivot end, of the bascule span and also the foot of the triangular counterweight tower; pier III supporting the vertical leg of the tower which carries the counterweight trunnion at its apex. The dead load on pier I is zero, on pier II, the weight of the moving leaf plus a portion of the fixed counterweight tower, and on pier III, the weight of the counterweight plus the remaining portion of the tower.

These loads are constant and vertical for any position of the leaf and are applied directly over the center of each pier. Each pier, in fact, is a pair of cylinders braced together by concrete girders transversely and piers II and III are tied together longitudinally as well. These longitudinal ties also form retaining walls holding the earth fill under the roadway and are themselves tied together transversely. These walls are necessary on account of a small slip alongside and to the north of the bridge and also to give clearance for the movement of the counterweights as hereinafter described.

Superstructure.—The superstructure consists of a through Warren truss main double track span, with subdivided panels and inclined top chords 260 ft. long between end bearings and a 58 ft. counterweight tower span designed for Coopers E-60 loading, in accordance with the Illinois Central standard specifications. The principles of counterbalancing and operation are much the same as in other bridges of this type. The counterbalancing, however, is effected by a pair of concrete slabs, termed "wing counterweights," one for each truss, which for this large bridge were found more economical, on account of the increase in leverage thus gained, than the single block of counterweight ofttimes used. They are 5 ft. 7 in. thick, 60 ft. high and 37 ft. wide and are built around the structural steel members of the counterweight trusses which support them and are reinforced in vertical planes with ¾ in. round rods and in horizontal planes with ½ in. square rods. In addition 3 in. expanded metal is placed 2 in. from outer faces of the concrete. Each concrete counterweight weighs approximately 885 tons at 148 lb. per cubic foot. The rectangular apertures showing in the face of the counterweight are for the purpose of adding adjustment blocks to obtain the exact required weight. The calculations were based on half of the number of these apertures being filled when the bridge is in equilibrium. The total weight of the blocks equals 7 per cent of the total counterweight.

As the bridge opens the counterweights move entirely outside the range of the railroad clearance and when the bridge is fully open their lowest point is 8 ft. below the base of rail. The vertical retaining walls between piers II and III holding the earth fill beneath the tracks permit such movement below the base of rail.

In order to support the concrete counterweights concentrically about the counterweight trusses the section above the railroad clearance of each tower truss is offset and overhangs so that the horizontal distance between center lines of the upper and lower sections is 5 ft., a deep portal girder in both the planes of the vertical and inclined tower posts extending between the tower trusses amply providing for the eccentric loading from the counterweight trunnions which together with the counterweight trusses are centrally located with respect to the overhanging upper section of the tower trusses.

The connterweight trusses in moving do not interfere with the upper section of the tower, since the single trunning bearing, typical of these bridges is used and by virtue of the offset above described the counterweights proper clear the lower section of the tower in moving along side.

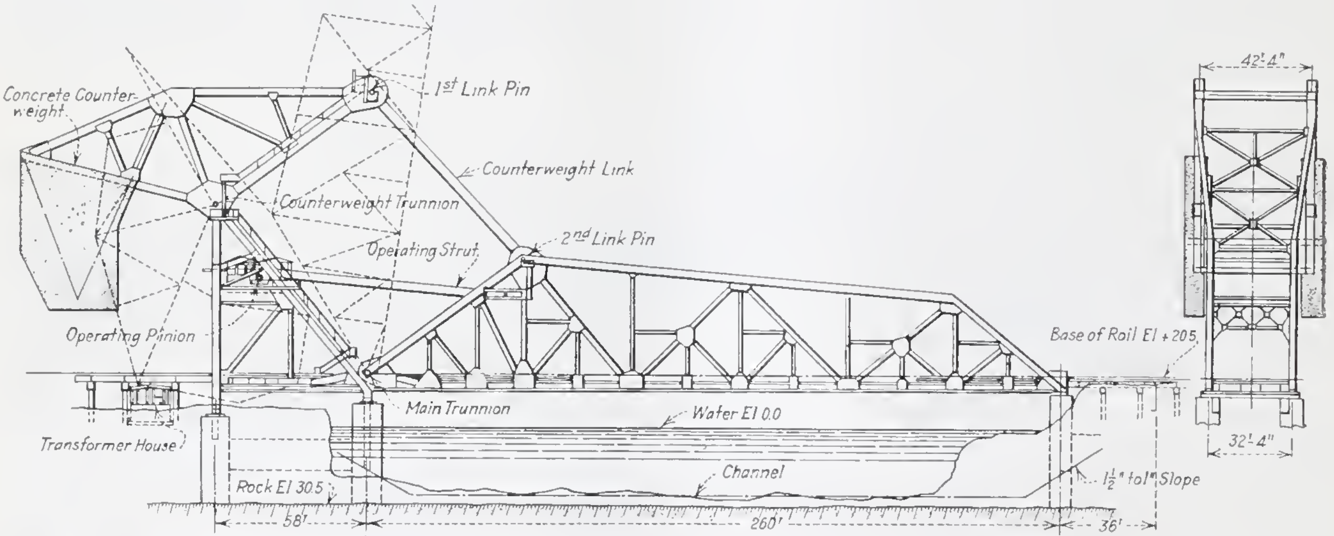
The lower section of the tower trusses being in line with the main trusses of the moving leaf, it will be seen that the counterweight trusses, which are in line with the upper sections of the tower trusses, will be 5 ft. off center with the main trusses of the bascule span; the two counterweight links (structural members) connecting the counterweight trusses with the hip of the moving leaf trusses and 85 ft. 7 9/16 in. long between connection pins, are therefore not parallel with each other in plan, being 42 ft. 4 in. between center lines at the counterweight end and 32 ft. 4 in. between center lines at the moving leaf end. These members are in direct tension transmitting the counterbalancing effect between counterweight and leaf and are braced together by struts and diagonals to take up the horizontal component of the link stress due to the 10 ft. difference in horizontal distance between centers at either end.

Operation.—The bridge is opened or closed in 1¾ minutes, being operated in the usual manner characteristic of this type, by means of straight racks bolted to a pair of operating struts, one pivoted to the end post of each truss, which are engaged by operating pinions located in the portal of the counterweight tower. The pinions are actuated through an equalizer and reduction gears by two 150 H.P. electric A.C. motors on a 440-volt 3-phase 60-cycle circuit, all located in a stationary fireproof cabin built in the portal of the tower above the overhead railroad clearance line. The electrical equipment and controllers together with a 62 H.P. gasoline engine for emergency drive are all located under the same roof with the operator thus facilitating inspection and maintenance.

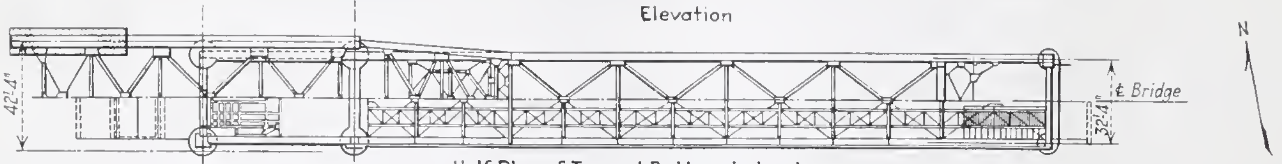
On account of the unprecedented size of this bridge it was considered advisable to use an air buffer, in addition to the oak bumping blocks ordinarily employed, on the operating strut, which comes into play when the bridge reaches the nearly open position. It consists of an air cylinder with 15 in. bore and 23½ in. stroke secured to the top of each strut near the moving leaf end; the piston rod is 4 in. in diameter and 6 ft. 3 in. long free to move in a guide casting secured to the strut at the mid-point of the piston rod extended. The rod is normally held in its extended position by a pair of coiled springs, one end secured to the piston and the other to the guide casting. When the bridge nears the limit of its opening the extended piston rods come into contact with a short I-beam bumping girder secured to the inclined post of the counterweight tower in the path of the operating strut and the compression of the air in the cylinder gradually arrests any further movement of the bridge after the power has been cut off and motor brakes applied. Valves in the cylinder head allow adjustment so as to secure proper cushioning effect. The other end of the cylinder is open to allow the return of the piston by the force of the springs to the extended position when the bridge is lowered thus being in correct position for the next opening. This device is a new feature and if proven satisfactory it will be used on such bridges in the future. A similar air buffer is located underneath the front end of the leaf which comes into play when the bridge closes, the piston rod coming into contact with the bridge seat of the rest pier.

The bridge is locked to the bridge shoe at the front end by motor driven latch bars moving in guides in the bottom chords of the main trusses, and controlled by the bridge operator. These locks are interlocked with the train signals so that the operator can not obtain current for opening them until the signals for trains approaching the bridge are set at danger. Likewise no current is available for the bridge operating motors until the locks are fully open when it is impossible to set the train signals at clear. The usual electric contact devices automatically break the current when the bridge has nearly reached its limiting positions and the motor brakes are automatically applied. An emergency brake is also provided acting on each operating strut incorporated with the operating strut guide. The brake is operated by single action compressed air cylinders, in line with the strut secured to flanges on the bottom of the guide. The pistons of the cylinders are connected by means of connecting levers and eccentrics to eight brake shoes—four each for the top and bottom flanges of the strut. The operator applies the brakes by admitting compressed air into the cylinders, a control valve being located in the operator's cabin immediately adjacent to the leaf motor controllers. A supply of compressed air is maintained by an air compressor inside the cabin and an air tank just outside the cabin overhead. The emergency brake is for use when the ordinary motor brakes are insufficient in case of accident to the operating machinery or other emergency and also serves as a positive lock for the bridge in any position irrespective of the bridge operating machinery. They also relieve this machinery from the stress due to the shock of applying emergency braking forces, on an intermediate shaft of the operating machinery, which method was employed before this air brake was developed, and the safety of these brakes, therefore, is not dependent upon the gears, shafts and other machinery parts intermediate between the point of application and the operating pinion and rack. They are not even dependent upon the teeth of the racks and pinions, being applied directly on the structural flanges of the operating struts.

Erection.—On account of the new location of the bridge (see Fig. 1) no interruption of railroad traffic, during construction of the new bridge, was occasioned, but it was necessary to avoid interference with river traffic during the period of



Elevation



Half Plan of Top and Bottom Laterals

Fig. 2—General Plan and Elevation of 200-Ft. Span Single Leaf Bascule Bridge.

erection which necessitated erection in the open position. The tower, counterweight links and counterweight trusses were erected from the timber gantry-like falsework and the moving leaf by derricks supported on the leaf itself and moved up as the steel was placed in position, much on the order of the steel frame in a tall building. The method of erecting the tower and counterweight trusses constitutes a new departure in bridges of this character and was used on account of the heavy members in this part of the structure, the heaviest single members being the rear section of the bottom chord of the counterweight truss with trunnion, weighing 70 tons. The contractor considered it expedient to use the extra falsework in order to obtain a better purchase on, and greater facility in handling the material. Heretofore in similar bridges ordinary derricks located on the ground and on the moving leaf when carried to sufficient height were considered equal to the task of hoisting and placing the members in position for the tower and counterweight trusses as well as for the moving leaf.

Provision for Moving Superstructure to Comply with Proposed River Straightening.—An unusually interesting feature of the entire construction is the provision for turning the bridge through a horizontal angle of about 160° to provide for the proposed future straightening of the Chicago river between 12th St. and 16th St., which had to be taken into account when plans for the construction of a new bridge were being considered in 1915. Progress towards adopting plans for a new bridge were, in fact, halted by the advancement of the plans of the Chicago Railway Terminal Commission for straightening the Chicago river. The proposed new river channel would cross the St. Charles Air Line about 400 ft. westerly from the present river channel and the designers of the type of bridge finally adopted proposed a plan, after much study, of building the superstructure of the new bridge to span the present river channel with provision for revolving it intact on a circular track and rollers onto new substructure to be built to accommodate the future new river channel. This plan, for the first time proposed, permitted the building of a bascule bridge in one location and its operation in that location for as long a period of years as necessary, when it can be turned around across the future channel and operated in its reverse position.

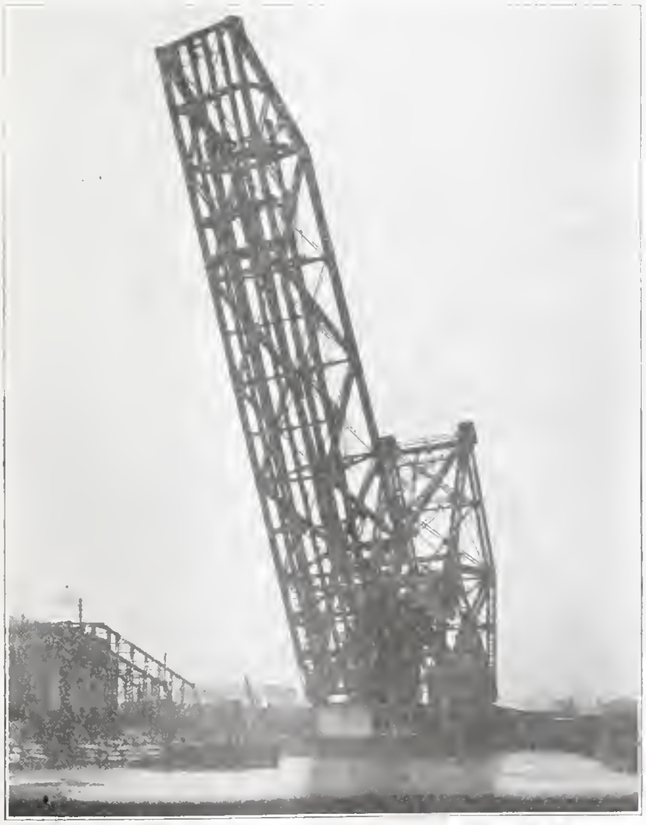


Fig. 3—Bridge With Leaf Raised.

This plan avoided any justifiable delay in conforming with the U. S. Government's requirement, to remove the obstructing center pivot swing bridge in the present channel, on the grounds of possible complete rebuilding again to comply with the future river straightening.

In moving the superstructure the bridge will be locked in a partly open position, by means of the operating struts, high enough to clear obstructions in the path of the front end of the leaf and the entire structure will then be revolved through the required arc until it comes into its new and final position. Practically the only change in the existing structure is the addition of a floor in the tower span, to be provided when the process of moving is undertaken.

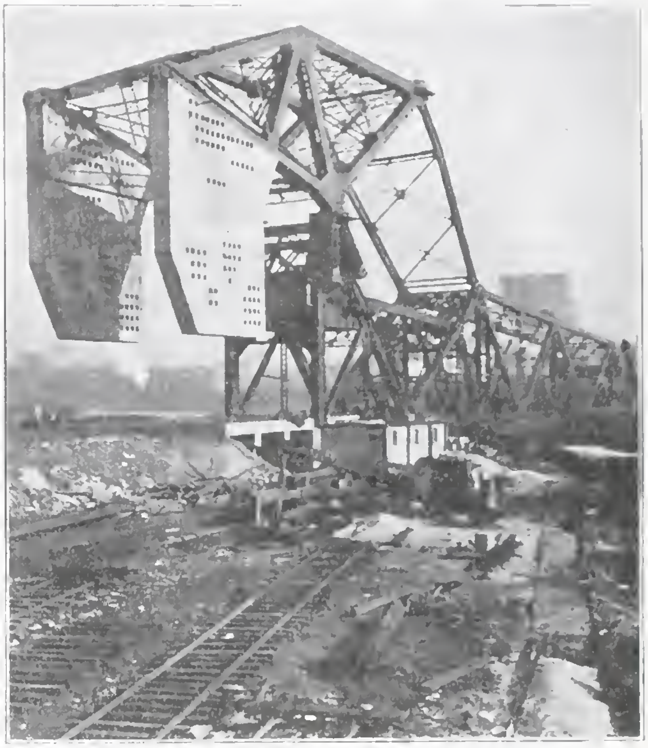


Fig. 4—Bridge in Closed Position.

Aside, therefore, from its huge size, this structure is unique in being the first bascule bridge designed to be moved bodily after completion.

Conclusion. The bridge was built by the Illinois Central R. R. under the direction of Former Chief Engineer A. S. Baldwin and Present Chief Engineer F. L. Thompson. Maro Johnson, Assistant Engineer, assumed direct charge during construction of the sub and superstructure. The Strauss Bascule Bridge Co. acted as consulting engineers for the railway and were selected by the four railway companies interested to furnish the design under its patent rights and prepare the general detail plans for the structure and approve the shop plans. The Foundation Co. built the substructure, beginning construction October, 1917, and completing it in August, 1918. The American Bridge Co. (Gary plant) fabricated the steel and machinery which was erected by the Ferro-Construction Co. of Chicago who began work in October, 1918, but were interrupted by delays in receipt of material in November, resuming operations in February, 1919, and completed the erection with minor interruptions August, 1919. The structural steel weighs 1,544 tons and the trunnion pins and operating machinery 166 tons. The main trunnions are 25 in. in diameter, the counter weight trunnions 46 in. and the first and second link pins 20½ in. and 31 in. respectively.

Mass Meeting of Chicago Technical Employes.—The Chicago Local, No. 14 of the International Federation of Technical Engineers', Architects' and Draftsmen's Union, held a mass meeting in the Aryan Grotto Theater, Chicago, on Dec. 11. Short addresses were delivered by Col. Henry A. Allen of the 108th Illinois Engineers, and by Oscar Nelson, Vice President of the Chicago Federation of Labor. The principal address of the evening was made by Anthony J. Oliver, President of the International Federation which is now composed of some 40 local unions representing a membership of over 6,000.

Advantages of the Slope Deflection Method of Analyzing Statically-Indeterminate Structures

By M. GRODSKY

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The increasing use of statically indeterminate structures warrants paying more careful attention to their analysis than has been done heretofore.

The usual methods of analyzing rigid frames and statically-indeterminate structures were the "elastic" and the "least work." The "elastic" method is outlined in "Modern Framed Structures," by Johnson, Bryan and Turneaure, Vol. 2, beginning with page 383 of the 9th edition. The method of "least work" is mentioned in several textbooks, but nowhere is it worked out to an extent of completeness desirable for the practicing engineer. Of the two methods, that of "least work" is the more comprehensive and also the more powerful.

It cannot be said that the two methods were popular with the average engineer, whenever he had to analyze a statically-indeterminate structure. He had heard of them, but was discouraged by the amount and character of the calculations they require. To make matters worse there are practically no examples worked out in textbooks.

Recently there came into existence a third method which promises to be of real help to the engineer analyzing statically-indeterminate structures. It is the so-called "slope-deflection" method. While analysis by "slope-deflection" gives the same results as by "least work,"[*] slope deflection possesses several advantages over the latter. These are as follows:

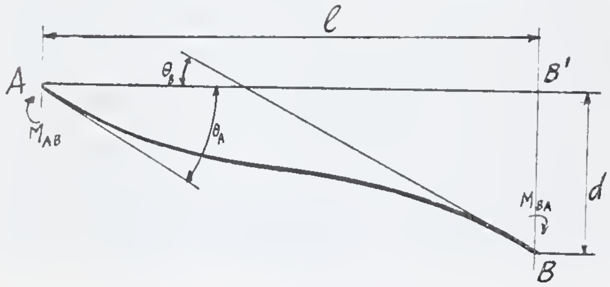


Fig. 1

1. The calculations are very much simpler in the "slope-deflection."

2. The "slope-deflection" does not involve any calculus. This is a great advantage, as the average engineer, not using calculus often, is cautious in applying it, and has a little distrust to results obtained through it. The "slope-deflection" requires only the solution of algebraic equations of a simple type.

3. While the fundamental equation of the "slope-deflection" is as easy to remember as that of "least work," the practical application of it to a case in hand is easier and not so involved as that of "least work."

In the Sept. 24, 1919 issue of "Engineering and Contracting" there were analyzed two statically indeterminate structures by "least work." It will be interesting for comparison of advantages of the two methods to analyze the same cases by "slope-deflection."

It is proper now to make a few preliminary remarks about this method. The fundamental equation is $M_{AB} = 2E\,I/l\,(2\theta_A + \theta_B - 3\,d/l)$, where

M_{AB} is the moment at the end A of member AB,

I is the average moment of inertia of the member,

l is the length of span of the member,

θ_A is the tangent of the angle at A which the deformed elastic axis makes with its original position,

θ_B is similarly the tangent at B, and

d is the deflection of one end of the member, measured on a line perpendicular to the original position of the member. As regards signs, M_{AB} is positive when causing clockwise rotation θ_A and θ_B are positive when the tangent is turned in a clockwise direction from its initial position and d is positive when the deflecting end of the member moves clockwise with reference to the other end.

As shown in Fig. 1 M_{AB}, M_{BA}, θ_A, θ_B and d are all positive; the original elastic line being AB', and the deflection d is that of end B from original position B'.

For any load on member AB a factor (F) is added to or subtracted from the equation for M. This factor is equal to the moment at the end of a fixed beam with same span and load. Its sign is not governed by the usual consideration of which side of the beam is in tension, but by the rotation it causes. Thus for a uniform load of w lbs. per ft. the factor is $wl^2/12$, and for the end A of member AB (Fig. 2) its sign is minus, because it causes anticlockwise rotation. At the end B its sign is plus because it causes clockwise rotation. Table 1 shows the values of the factors for ordinary loadings.

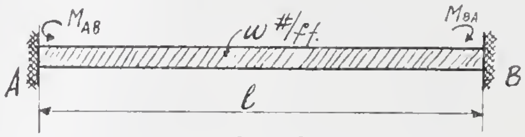


Fig. 2

These factors are easily worked out: either analytically or by area-moments.

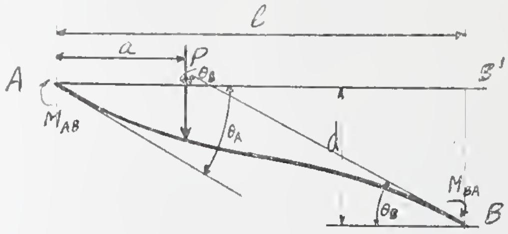


Fig. 3

Thus in Fig. 3:

$$M_{AB} = \frac{2EI}{l}\left(2\theta_A + \theta_B - \frac{3d}{l}\right) - \frac{Pa(l-a)^2}{l^2}$$

$$M_{BA} = \frac{2EI}{l}\left(\theta_A + 2\theta_B - \frac{3d}{l}\right) + \frac{Pa^2(l-a)}{l^2}$$

APPLICATION.

Example 1—

Take a beam continuous over two supports as shown in Fig. 4. Assume a constant moment of inertia and a uniform load of w lbs. per ft.

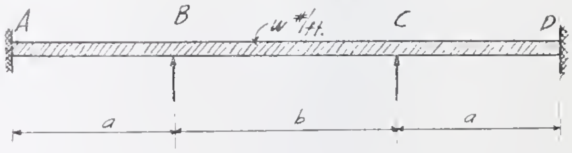


Fig. 4.

(A) No settlement of supports $\therefore d = o$.

$\theta_A = o$. Elastic curve horizontal at A due to fixity.

$\theta_D = o$. Elastic curve horizontal at D due to fixity.

$\theta_C = -\theta_B$. Structure is symmetrical about the middle.

$$M_{AB} = \frac{2EI}{a}\left(2\theta_A + \theta_B - \frac{3d}{a}\right) - \frac{wa^2}{12} = \frac{2EI\theta_B}{a} - \frac{wa^2}{12}$$

$(\theta_A = o,\ d = o)$.

$$M_{BA} = \frac{2EI}{a}\left(\theta_A + 2\theta_B - \frac{3d}{a}\right) + \frac{wa^2}{12} = \frac{4EI\theta_B}{a} + \frac{wa^2}{12}$$

$(\theta_A = o,\ d = o)$.

$$M_{BC} = \frac{2EI}{b}\left(2\theta_B + \theta_C - \frac{3d}{b}\right) - \frac{wb^2}{12} = \frac{2EI\theta_B}{b} - \frac{wb^2}{12}$$

$(\theta_C = -\theta_B)$.

From a well-known principle in mechanics, viz. that the summation of external moments at a joint in equilibrium equals zero, ΣM about joint $B = o$. $\therefore M_{BA} + M_{BC} = o$.

$$\frac{4EI\theta_B}{a} + \frac{wa^2}{12} + \frac{2EI\theta_B}{b} - \frac{wb^2}{12} = o$$

---

[*] Both methods usually neglect work done by axial forces.

$$2EI\Theta_1\left(\frac{2}{a}+\frac{1}{b}\right)=\frac{wb^2}{12}-\frac{wa^2}{12}$$

$$2EI\Theta_B=\frac{(wb^2-wa^2)}{12}\cdot\frac{ab}{(2b+a)}$$

Substitute this value in equations for M_{AB}, M_{BA}, M_{BC}.

$$M_{AB}=\frac{2EI\Theta_B}{a}-\frac{wa^2}{12}=\frac{(wb^2-wa^2)}{12}\cdot\frac{b}{(2b+a)}-\frac{wa^2}{12}=\frac{-w(a^2+3a^2b-b^3)}{12(2b+a)}$$

$$M_{BC}=\frac{2EI\Theta_B}{b}-\frac{wb^2}{12}=\frac{(wb^2-wa^2)}{12}\cdot\frac{a}{(2b+a)}-\frac{wb^2}{12}=\frac{-w(a^3+2b^3)}{12(a+2b)}$$

Note: M_{BC} is the moment at the end B of member BC, etc.

(B) Assume supports B and C to settle an amount equal to d. Then

$$M_{AB}=\frac{2EI}{a}\left(2\Theta_A+\Theta_B-\frac{3d}{a}\right)-\frac{wa^2}{12}=\frac{2EI\Theta_B}{a}-\frac{6EId}{a^2}-\frac{wa^2}{12}$$

$$M_{BA}=\frac{2EI}{a}\left(\Theta_A+2\Theta_B-\frac{3d}{a}\right)-\frac{wa^2}{12}=\frac{4EI\Theta_B}{a}-\frac{6EId}{a^2}+\frac{wa^2}{12}$$

$$M_{BC}=\frac{2EI}{b}\left(2\Theta_B+\Theta_C\right)-\frac{wb^2}{12}=\frac{2EI\Theta_B}{b}-\frac{wb^2}{12}\dagger$$

$$M_{BA}+M_{BC}=o$$

$$\therefore 2EI\Theta_B\left(\frac{2}{a}+\frac{1}{b}\right)-\frac{6EId}{a^2}+\frac{wa^2}{12}-\frac{wb^2}{12}=o$$

$$2EI\Theta_B\left(\frac{2b+a}{ab}\right)=\frac{wb^2}{12}-\frac{wa^2}{12}+\frac{6EId}{a^2}$$

$$2EI\Theta_B=\frac{(wb^2-wa^2)}{12}\cdot\frac{ab}{2b+a}+\frac{6EId}{a^2}\cdot\frac{ab}{2b+a}$$

Substitute in M_{AB} and M_{BC}

$$M_{AB}=\frac{wb^2-wa^2}{12}\cdot\frac{b}{2b+a}+\frac{6EId}{a^2}\cdot\frac{b}{2b+a}-\frac{6EId}{a^2}-\frac{wa^2}{12}$$

$$=\frac{w}{12(2b+a)}(b^3-a^2b-2a^2b-a^3)+\frac{6EId}{a^2(2b+a)}(b-2b-a)$$

$$=\frac{-w(a^3+3a^2b-b^3)}{12(2b+a)}-\frac{6EId(a+b)}{a^2(2b+a)}$$

Similarly $M_{BC}=\dfrac{-w(a^3+2b^3)}{12(2b+a)}+\dfrac{6EId}{a(2b+a)}$

M_{BA} is found in a similar way.

Knowing the moments at the supports the reactions are found easily. Take in Fig. 5 AB as a free member. It being in equilibrium the summation of moments about any point equals zero. Hence taking moments about B

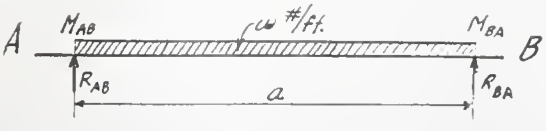


Fig. 5

$$\Sigma M=M_{AB}+R_{AB}\times a-\frac{wa^2}{2}+M_{BA}=o$$

From which R_{AB} is easily obtained.

(C) The moments at supports and reactions for any number of spans and for supports at different levels may be obtained by a similar procedure.

Example 2:

Consider a symmetrical frame shown in Fig. 6 loaded with various symmetrical loads. Due to symmetry the tangent at C is horizontal ($\Theta_C=o$); $\Theta_D=-\Theta_B$; also $d=o$. Due to fixity of ends $\Theta_A=o$, $\Theta_E=o$. Under such conditions only half of the figure need be considered.

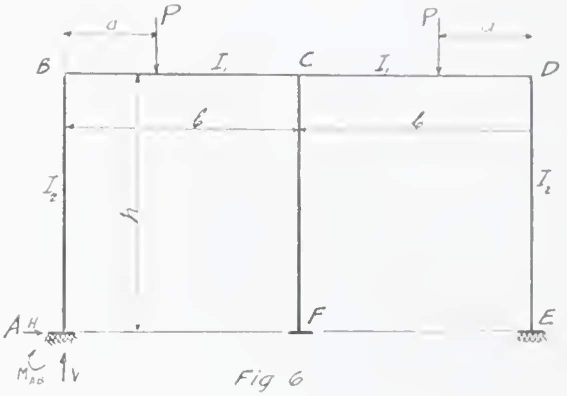


Fig 6

(A) Any Symmetrical Vertical Load.

$$M_{AB}=\frac{2EI_2\Theta_B}{h};\quad M_{BC}=\frac{2EI_1\times 2\Theta_B}{b}-F_{BC}\quad (F\text{—loading factor.})$$

$$M_{BA}=\frac{4EI_2\Theta_B}{h};\quad M_{CB}=\frac{2EI_1\Theta_B}{b}+F_{CB}$$

ΣM at joint $B=o$ $\quad\therefore M_{BA}+M_{BC}=o$

$$\frac{4EI_2\Theta_B}{h}+\frac{4EI_1\Theta_B}{b}-F_{BC}=o\qquad \Theta_B=\frac{F_{BC}\,bh}{4E(I_2b+I_1h)}$$

Substitute in values for Moments:

$$M_{AB}=\frac{2EI_2}{h}\cdot\frac{F_{BC}\,bh}{(I_1h+I_2b)4E}=\frac{I_2b}{(I_2b+I_1h)}\cdot\frac{F_{BC}}{2}$$

$$M_{BA}=\frac{I_2b}{(I_2b+I_1h)}F_{BC}$$

$$M_{BC}=-M_{BA}=-\frac{I_2b}{(I_2b+I_1h)}F_{BC}$$

$$M_{CB}=\frac{2EI_1bh\times F_{BC}}{b4E(I_2b+I_1h)}+F_{CB}=\frac{I_1h}{(I_2b+I_1h)}\cdot\frac{F_{BC}}{2}+F_{CB}$$

By considering AB a free member and applying principle $\Sigma M=o$, we obtain H. Thus in Fig. 7 $\Sigma M=M_{AB}+M_{BA}-Hh=o$ $\quad\therefore\ Hh=M_{AB}+M_{BA}=\dfrac{I_2b}{(I_2b+I_1h)}\cdot\dfrac{3F_{BC}}{2}$

By considering BC a free member and applying $\Sigma M=o$, we obtain V. Thus in Fig. 8 $\Sigma M=M_{BC}+M_{CB}+Vb-\Sigma Pa=o$ (where a is lever arm of load). $\therefore\ Vb=\Sigma Pa-M_{BC}-M_{CB}$

Results due to three cases of vertical loading are shown in Table 2.

(B) Any Symmetrical Horizontal Load.

$$M_{AB}=2EI_2\frac{\Theta_B}{h}-F_{AB}\qquad M_{BC}=2E\frac{I_1}{b}\times 2\Theta_B$$

$$M_{BA}=\frac{4EI_2\Theta_B}{h}+F_{BA}\qquad M_{CB}=\frac{2EI_1}{b}\Theta_B$$

$\Sigma M=o$ $\quad\therefore M_{BA}+M_{BC}=o$

$$\therefore\ 4E\Theta_B\left(\frac{I_2}{h}+\frac{I_1}{b}\right)+F_{BA}=o\qquad \Theta_B=-F_{BA}\frac{bh}{4E(I_2b+I_1h)}$$

Substituting this value of Θ_B in values of moments:

$$M_{AB}=-\frac{bI_2}{(bI_2+hI_1)}\cdot\frac{F_{BA}}{2}-F_{AB}$$

$$M_{BA}=\frac{hI_1}{(hI_1+bI_2)}F_{BA}$$

---

†As there is in span BC no movement of one end relative to the other, d for span BC = o.

$$M_{BC} = -\frac{bI_1}{hI_1 + bI_2} F_{BA}$$

$$M_{CD} = -\frac{hI_1}{hI_1 + bI_2} \frac{F_{BA}}{2}$$

Values of H and V may be obtained as before. Table 3 contains results for three cases of horizontal loading.

In both vertical and horizontal loadings numerical substitutions are exceedingly simple and hence omitted here.

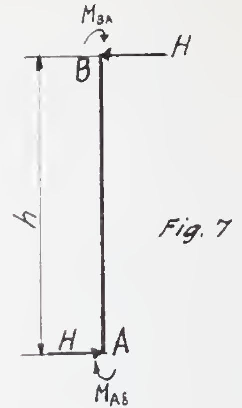


Fig. 7

Example 3:

In order to compare the amount of calculations involved in "Slope-deflection" and in "Least Work," one case from Example 2 is worked out here by the method of "least work."

Consider frame and load as shown in Fig. 6. Due to symmetry of frame only half of it need be considered. There is no work in member CF.

Moment in AB $M = M_A - Hx$

$$\frac{\partial M}{\partial M_A} = 1; \quad \frac{\partial M}{\partial H} = -x; \quad \frac{\partial M}{\partial V} = o$$

$$\frac{\partial\,(\text{Work})}{\partial M_A} = \frac{1}{I_2}\int_o^h (M_A - Hx)\,dx = \frac{M_A h}{I_2} - \frac{Hb^2}{2I_2} \text{ (omitting E)}$$

$$\frac{\partial W}{\partial H} = \frac{1}{I_2}\int_o^h (M_A - Hx)(-x)\,dx = \frac{Hb^3}{3I_2} - \frac{M_A h^2}{2I_2}$$

$$\frac{\partial W}{\partial V} = O$$

Moment in BC $M = M_A - Hh + Vx.$

$$\frac{\partial M}{\partial M_A} = 1; \quad \frac{\partial M}{\partial H} = -h; \quad \frac{\partial M}{\partial V} = x$$

$$\frac{\partial W}{\partial M_A} = \frac{1}{1}\int_o^b (M_A - Hh + Vx)\,dx = \frac{M_A b}{I_1} - \frac{Hhb}{I_1} + \frac{Vb^2}{2I_1}$$

$$\frac{\partial w}{\partial H} = -h \times \frac{\partial w}{\partial M_A} = -\frac{M_A bh}{I_1} + \frac{Hh^2 b}{I_1} - \frac{Vhb^2}{2I_1}$$

$$\frac{\partial w}{\partial V} = \frac{1}{I_1}\int_o^b (M_A - Hh + Vx)\,x\,dx = \frac{M_A b^2}{2I_1} - \frac{Hhb^2}{2I_1} + \frac{Vb^3}{3I_1}$$

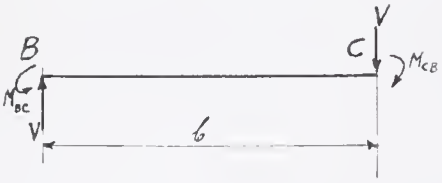


Fig. 8

Additional moment in BC (due to load P) $= -P(x - a)$.

$$\frac{\partial M}{\partial M_{A_1}}, \frac{\partial M}{\partial H_1}, \frac{\partial M}{\partial V}$$ same as before.

$$\frac{\partial W}{\partial M} = -\frac{P}{I_1}\int_a^b (x - a)\,dx = -\frac{P}{I_1}\left(\frac{x^2}{2} - ax\right)_a^b = -\frac{P}{I_1}\frac{(b-a)^2}{2}$$

$$\frac{\partial W}{\partial H} = -h \times \frac{\partial W}{\partial M} = \frac{Ph}{I_1}\frac{(b-a)^2}{2}$$

$$\frac{\partial W}{\partial V} = -\frac{P}{I_1}\int_a^b (x - a)\,x\,dx = -\frac{P}{I_1}\left(\frac{x^3}{3} - \frac{ax^2}{2}\right)_a^b = -\frac{P}{6I_1}(2b^3 - 3ab^2 + a^3)$$

Equations of work for both members:

$$\frac{\partial W}{\partial M_A} = o$$

$$\therefore \frac{M_A h}{I_2} - \frac{Hh^2}{2I_2} + \frac{M_A b}{I_1} - \frac{Hhb}{I_1} + \frac{Vb^2}{2I_1} - \frac{P(b-a)^2}{2I_1} = o$$

$$\text{or } M_A(hI_1 + bI_2) - \frac{Hb}{2}(bI_1 + 2bI_2) + \frac{Vb^2 I_2}{2} = \frac{PI_2}{2}(b-a)^2 \quad (1)$$

$$\frac{\partial W}{\partial H} = o$$

$$\therefore \frac{Hh^3}{3I_2} - \frac{M_A h^2}{2I_2} - \frac{M_A bh}{I_1} + \frac{Hh^2 b}{I_1} - \frac{Vb^2 h}{2I_1} + \frac{Ph}{2I_1}(b-a)^2 = o$$

TABLE 1.

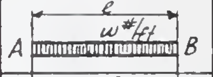
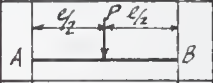
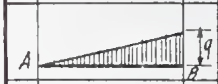
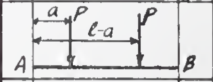
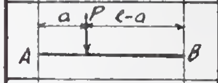
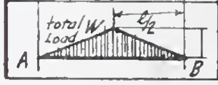
Loading	F_{AB} mom. at left hand end	F_{BA} mom. at right hand end
	$-\frac{wl^2}{12}$	$+\frac{wl^2}{12}$
	$-\frac{Pl}{8}$	$+\frac{Pl}{8}$
	$-q\frac{l^2}{30}$	$+q\frac{l^2}{20}$
	$-\frac{Pa(l-a)}{l}$	$+\frac{Pa(l-a)}{l}$
	$-\frac{Pa(l-a)^2}{l^2}$	$+\frac{Pa^2(l-a)}{l^2}$
	$-\frac{5}{48}Wl$	$+\frac{5}{48}Wl$

TABLE 2.

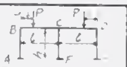
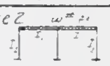
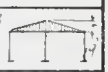
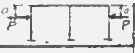
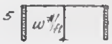
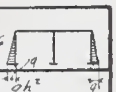
	VERTICAL LOADS		
	Case 1 	Case 2 	Case 3 
F_{BC}	$\frac{Pa(l-a)^2}{l^2}$	$\frac{wl^2}{12}$	$q\frac{l^2}{30}$
F_{CB}	$\frac{Pa^2(l-a)}{l^2}$	$\frac{wl^2}{12}$	$q\frac{l^2}{20}$
M_{AB}	$\frac{Pa(l-a)^2}{2l}\frac{I_2}{(lI_2+hI_1)}$	$\frac{wl^3}{24}\frac{I_2}{(lI_2+hI_1)}$	$q\frac{l^3}{60}\frac{I_2}{(lI_2+hI_1)}$
M_{BA}	$\frac{Pa(l-a)^2}{l}\frac{I_2}{(lI_2+hI_1)}$	$\frac{wl^3}{12}\frac{I_2}{(lI_2+hI_1)}$	$+q\frac{l^3}{30}\frac{I_2}{(lI_2+hI_1)}$
M_{BC}	$-\frac{Pa(l-a)^2}{l}\frac{I_2}{(lI_2+hI_1)}$	$-\frac{wl^3}{12}\frac{I_2}{(lI_2+hI_1)}$	$-q\frac{l^3}{30}\frac{I_2}{(lI_2+hI_1)}$
M_{CB}	$\frac{Pa(l-a)^2 I_1 h}{2l^2(lI_2+hI_1)}+\frac{Pa^2(l-a)}{l^2}$	$\frac{wl^2 I_1 h}{24(lI_2+hI_1)}+\frac{wl^2}{12}$	$q\frac{l^2 I_1 h}{60(lI_2+hI_1)}+q\frac{l^2}{20}$
H	$\frac{3Pa(l-a)^2}{2lh}\frac{I_2}{(lI_2+hI_1)}$	$\frac{wl^3}{8h}\frac{I_2}{(lI_2+hI_1)}$	$q\frac{l^3}{20h}\frac{I_2}{(lI_2+hI_1)}$
V	$\frac{Pa(l-a)(2lI_2-hI_1)}{2l^3(lI_2+hI_1)}+\frac{P(l-a)^2(l+a)}{l^3}$	$\frac{wl(3hI_1+4lI_2)}{8(hI_1+lI_2)}$	$\frac{ql(2lI_2-hI_1)}{60(lI_2+hI_1)}+\frac{7ql}{60}$

TABLE 3.

	HORISONTAL LOADS		
	case 4 	Case 5 	Case 6 
F_{AB}	$\frac{Pa^2(h-a)}{h^2}$	$\frac{wh^2}{12}$	$q\frac{h^2}{20}$
F_{BA}	$\frac{Pa(h-a)^2}{h^3}$	$\frac{wh^2}{12}$	$q\frac{h^2}{30}$
M_{AB}	$\frac{-lI_2}{2h^2}\frac{Pa(h-a)^2}{(lI_2+hI_1)}-\frac{Pa^2(h-a)}{h^2}$	$\frac{-lI_2}{(lI_2+hI_1)}\frac{wh^2}{24}-\frac{wh^2}{12}$	$\frac{-lI_2}{(lI_2+hI_1)}q\frac{h^2}{60}-q\frac{h^2}{20}$
M_{BC} $=-M_{BA}$	$-\frac{Pa(h-a)^2}{h}\frac{I_1}{(lI_2+hI_1)}$	$-\frac{wh^3I_1}{12(lI_1+hI_1)}$	$-\frac{qh^3I_1}{30(lI_2+hI_1)}$
M_{CB}	$-\frac{Pa(h-a)^2I_1}{2h(lI_2+hI_1)}$	$-\frac{wh^3I_1}{24(lI_2+hI_1)}$	$-\frac{qh^3I_1}{60(lI_2+hI_1)}$
H	$\frac{Pa(h-a)^2(lI_2-2hI_1)}{2h^3(lI_2+hI_1)}+\frac{Pa}{h^3}(h^2+ah-a^2)$	$\frac{wh(lI_2-2hI_1)}{24(lI_2+hI_1)}+\frac{7}{12}wh$	$\frac{qh(lI_2-hI_1)}{60(lI_2+hI_1)}+\frac{53}{60}qh$
V	$\frac{3Pa(h-a)^2I_1}{2hl(lI_2+hI_1)}$	$\frac{wh^3I_1}{8l(lI_2+hI_1)}$	$\frac{qh^3I_1}{20l(lI_2+hI_1)}$

$$\text{or } Hh(hI_1+3bI_2) - \frac{3}{2}M_A(hI_1+2bI_2) - \frac{3}{2}Vb^2I_2 = \frac{-3PI_2}{2}(b-a)^2 \quad (2)$$

$$\frac{\partial W}{\partial V} = 0$$

$$\therefore \frac{M_Ab^2}{2I_1} - \frac{Hhb^2}{2I_1} + \frac{Vb^3}{3I_1} - \frac{P}{6I_1}(2b^3 - 3ab^2 + a^3) = 0$$

$$\text{or } 3M_Ab^2 - 3Hhb^2 + 2Vb^3 = P(2b^3 - 3ab^2 + a^3) \quad (3)$$

Eliminate V.

From (1)

$$Vb^2 = P(b-a)^2 - \frac{2M_A}{I_2}(hI_1 + bI_2) + \frac{Hh}{I_2}(hI_1 + 2bI_2) \quad \ldots\ldots (4)$$

From (2)

$$Vb^2 = P(b-a)^2 - \frac{M_A}{I_2}(hI_1 + 2bI_2) + \frac{2Hh}{3I_2}(hI_1 + 3bI_2) \quad \ldots (5)$$

From (3)

$$Vb^2 = \frac{P}{2b}(2b^3 - 3ab^2 + a^3) - \frac{3M_Ab}{2} + \frac{3Hhb}{2} \quad (6)$$

Subtract (4) from (5).

$$0 = \frac{M_A}{I_2}(2hI_1 - hI_1) - \frac{Hh}{I_2}\left(hI_1 - \frac{2hI_1}{3}\right)$$

$$0 = \frac{M_AhI_1}{I_2} - \frac{Hh^2I_1}{3I_2}$$

$$3M_A = Hh \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Subtract (6) from (4)

$$0 = P\left(-2ba + a^2 + \frac{3}{2}ab - \frac{a^2}{2b}\right) - \frac{M_A}{I_2}\left(2hI_1 + 2bI_2 - \frac{3bI_2}{2}\right) + \frac{Hh}{I_2}\left(hI_1 + 2bI_2 - \frac{3bI_2}{2}\right) \text{ or}$$

$$P\left(-\frac{ba}{2} + a^2 - \frac{a^3}{2b}\right) = \frac{M_A}{I_2}\left(2hI_1 + \frac{bI_2}{2}\right) - \frac{Hh}{I_2}\left(hI_1 + \frac{bI_2}{2}\right)$$

$$-\frac{Pa}{2b}(b-a)^2 = \frac{M_A}{2I_2}(4hI_1 + bI_2) - \frac{Hh}{2I_2}(2hI_1 + bI_2) \quad \ldots (8)$$

Solve for Hh from (8)

$$Hh = \frac{Pa(b-a)^2}{b}\,\frac{I_2}{(2hI_1 + bI_2)} + \frac{M_A(4hI_1 + bI_2)}{(2hI_1 + bI_2)} \quad \ldots\ldots\ldots (9)$$

Equate (7) and (9)

$$3M_A = \frac{Pa(b-a)^2I_2}{b(2hI_1 + bI_2)} + M_A\frac{(4hI_1 + bI_2)}{(2hI_1 + bI_2)}$$

$$\text{or } M_A\left[3 - \frac{4hI_1 + bI_2}{2hI_1 + bI_2}\right] = \frac{Pa(b-a)^2I_2}{b(2hI_1 + bI_2)}$$

$$M_A\,[6hI_1 + 3bI_2 - 4hI_1 - bI_2] = \frac{Pa(b-a)^2I_2}{b}$$

$$M_A\,(2hI_1 + 2bI_2) = \frac{Pa\,(h-a)^2}{b}\,I_2$$

$$M_A = \frac{Pa(b-a)^2}{2b}\,\frac{I_2}{(bI_2 + hI_1)} \quad \ldots\ldots (10)$$

$$\text{From (7)} \quad H = \frac{3M_A}{h} = \frac{3Pa(b-a)^2I_2}{2bh(bI_2 + hI_1)} \quad \ldots\ldots\ldots\ldots (11)$$

Knowing M_A and H, V may be obtained from Equations 1, 2 or 3.

This comparison of a simple case of symmetrical loading shows the advantage of the "slope-deflection" over the "least work."

For unsymmetrical frames and loads, the calculations by "slope-deflection" are only slightly increased; while by "least work" they are highly complicated. In another article such a comparison (for unsymmetrical frames and loads) may be worked out.

Analysis of Statically Indeterminate Structures by the Slope Deflection Method

A 214 page bulletin that should be of much value to the engineer designing statically indeterminate structures has been issued recently by the Engineering Experiment Station of the University of Illinois. The bulletin contains a mathematical analysis of the stresses in various structures, including continuous girders, two-legged rectangular bents trapezoidal bents, three-legged bents, rectangular frames and office building frames. The stresses are analyzed by the slope deflection method based upon the work of Otto Mohr and C. E. Greene as developed by Manderla, Mohr, Kunz and Wilson and Maney.

The feature of the work which is entitled to especial attention is the separation of the moments in a member into two parts. One part depends upon the physical and geometrical properties of the member and the restraint of the ends of the member. The other part depends upon the external load to which the member is subjected. To illustrate, consider the case of a two-legged rectangular bent with equal legs and carrying any system of vertical loads on top. If the legs are hinged at the bases, the moment at the end A of the top member AB is given by the equation

$$M_{AB} = 3/10n\,[C_{AB} + C_{BA}]$$

in which C_{AB} and C_{BA} are constants depending upon the loading on the member AB. Values of the constants C are given in the bulletin for all types of loadings. In this way equations were derived for determining stresses in a large number of structures due to any system of loading. By substituting proper values for C the equations are applicable to the same frames carrying any specific system of loads.

Some statically indeterminate structures have been analyzed which are of special interest. The usual one-span girder with fixed ends (tangents to the elastic curve at the ends horizontal) has been modified to include the case in which the ends of the girder are restrained but are not fixed. That is, rotation at the end of the girder is resisted but not prevented entirely. Likewise the case is considered in which the supports are not on the same level. These modifications are carried throughout the treatment of continuous girders.

The effect of settlement and heaving of foundations is considered in the treatment of continuous girders, two-legged and three-legged bents. This treatment of two-legged bents should be of special interest to a designer of bents and towers.

In the treatment of the office building frames a number of interesting conditions were considered. These included, stresses in columns and girders due to settlement of one column, arrangement of loads on different panels to produce, maximum bending moments in the columns, likewise for maximum bending moment in the girders, and the moments in girders and columns due to eccentric loads on the exterior columns.

A number of illustrative numerical problems are given These include the following Moments in a four-span continuous girder with restrained (not fixed) ends where the supports are all on different levels, the lengths of all spans are different, and the loads on all spans are different; moments in a two-legged rectangular bent with fixed bases and a uniformly varying distributed load on both legs (in reality a section of a concrete culvert partly submerged in water), and moment due to settlement of the foundations of a two-legged rectangular bent with fixed bases.

The authors of the bulletin are W. M. Wilson, Assistant Professor of Civil Engineering; F. E. Rideout, Instructor in Theoretical and Applied Mechanics, and Camillo Weiss, Instructor in Structural Engineering, of the University of Illinois. The bulletin can be obtained from the Engineering Experiment Station, University of Illinois, Urbana, Ill., for $1

Sixty-nine Per Cent Capacity of Fabricating Shops Contracted for in November.—The records of the Bridge Builders & Structural Society as collected by its secretary, show that during the month of November, 1919, 69 per cent of the entire capacity of the bridge and structural shops of the country was contracted for.

Safety Measures for Hoisting in Building Operations

Useful suggestions for accident prevention in the building trades have been compiled by the Federal Board of Vocational Education in a bulletin, designed to form the basis of instruction in safety and hygiene in vocational schools. The following is abstracted from the bulletin:

Importance of Proper Location of Hoisting Equipment.—For buildings of considerable size a mechanical hoist of some kind is necessary. Steam hoisting engines are still the most common. Electric motors are often used to operate hoists when electric current is available.

The location of the hoist with reference to the work is important. During the early stages of construction it may be necessary to have the hoist located outside the foundation walls.

In handling material in construction work by means of a boom derrick it is important that the derrick be so located as to minimize the danger of injury from the boom as it swings, or in case it should drop. The workmen must guard against injury to the building or other workmen by swinging loads. Beams, structural steel, or other unwieldy loads are liable to swing and carry away some part of the building, scaffold, or strike persons or teams.

There are many contractors who prefer to put the hoist on the second floor as soon as possible, as this gets it more out of the way, and it is easier to protect the cables and signal cords. The location will be decided by the contractor according to the circumstances. The important consideration is the safety of the workmen. Wherever located, the hoist should be protected from weather and from falling objects. A substantial roof is very important. The full attention of the engineer is needed for his work and his efficiency is greatly increased by a feeling of security.

There are dangers that result from placing the hoisting engine on an upper floor. Vibration is more serious. There is much more danger of coal, tools, or material being dropped on some one below. There is the chance of water, oil, or cinders falling through to a lower floor and the fire risk is greater. These risks can be provided against by a good solid floor and protection against fire by a good fireproof protection under the boiler. The products of combustion are objectionable in a building and exhaust steam and steam from the safety valve may dangerously obscure the vision of workmen. If steam is brought to the engine from a central plant the hot pipes must be protected so that anyone passing will not by chance take hold of, or accidentally come in contact with them, and be burned.

Hoist shafts and elevators should be provided with gates or railings, and these should be located far enough from the opening to prevent anyone being struck by bucket or car while leaning over. All openings in the floor should be protected by toe boards.

All Brakes Must Be Absolutely Reliable.—Frequent tests and very careful inspection is necessary. Brake linings wear and require readjustment or renewal. The brakes must always be in condition to hold the maximum load. All hoists must always be kept under complete control at all times and particularly when lowering heavy loads.

Sometimes oil gets on brake drums and prevents the brake holding the load. A dog should be provided to hold the load when it is to be suspended for any time as a friction brake is not reliable.

Extemporized or makeshift brakes are sometimes used. Any form of brake that is not thoroughly dependable must be removed as, if left so it can be used, it is liable to be depended on and lead to serious accident.

In case of a failure of any part of the hoisting apparatus it endangers not only those in direct charge of the hoisting work, but other workmen who may not even know that they are in danger. An accident in hoisting has possibilities of such serious results that reliable men should have charge of such work.

Visual Signals Preferable.—The use of whistles as signals on a hoisting job is dangerous. The noise that is always present to a more or less degree may make serious confusion and cause accidents. The person giving the signals should always be in sight of the engineer. If this is not possible have another man located where he can see both the engineer and the man in charge who will pass the signals.

Perfect understanding of signals is very necessary. Uniform standard signals throughout the country are very desirable.

In case the signals are given by bell operated by cords or wires, these cords or wires must be guarded so that they will not be fouled in any way.

The proper operation of hoisting signals may be a life or death matter, and the system should be inspected and tested every time the engineer begins work. Cords or wires must be fully protected from injury where they pass through the floors. A good way to protect signal cords or wires is to incase them in wrought-iron pipes that are securely anchored in place. A good railing at least 7 ft. high is often used. It should be strongly braced.

Material hoists should not be used to carry workmen. They are seldom provided with proper safeguards and are often carelessly operated.

Workmen are much inclined to take chances, particularly if it will save them a little inconvenience. Riding on hoists and crane slings to avoid climbing ladders or stairs is dangerous and should not be allowed.

Reliable stop limits must be provided to prevent overwinding of the hoisting ropes.

There should always be at least two full turns of hoisting rope on the winding drum, and the end of the rope should be fastened securely by suitable clamps or zinc plugs. There is danger if the end of the rope is served to a spoke of the winding drum, as it may be whipped loose by rapid revolutions of the drum.

Precautions for Hand-Operated Hoists.—For small jobs and for some work on large jobs the hand-operated hoist or derrick, sometimes called a "breast derrick," is often used. The gears should be thoroughly protected and provided with a ratchet stop that will always hold the load at any point. Particular care must be used in lowering a load with the hand winch. The cranks, usually two in number, are loose, so one or both may be taken off. Extreme care must be exercised that these cranks do not come off unexpectedly. A brake is not usually provided and loads have to be lowered by the hand cranks. If one crank should slip off it would throw an unexpected load on the other man. His crank might be jerked from his hand; the load would cause a rapid revolution of the crank, and anyone near would be in danger. Often an extemporized brake is applied for lowering light loads. In this case the operator must be sure that the brake will hold the load. Before lowering the load by the brake both cranks must be removed to avoid the danger of their being thrown off and striking some one, and also because a rapid revolution of the cranks would cause a violent shaking of the whole derrick and may destroy the winding mechanism or unstep the derrick, unless it is very securely anchored on a solid footing.

In all cases where wire or hemp rope is wound on a spool it should wind on in smooth layers. If allowed to climb or spool on in irregular fashion it results in severe wear to the rope and often in irregular jerking that is dangerous, particularly when raising the load.

Proper lubrication of the hoisting rope is important not only to prevent rusting, but to prolong the life of the rope by reducing the wear. It also greatly reduces the tendency to climb on the drum. Precaution should always be taken to have a snatch block or guide pulley so located that the rope will be given a proper direction onto the winding drum. This guide pulley should be far enough away from the drum to avoid a tendency of the rope to climb. Much trouble may be caused by having the drum too near the pulley that changes the direction of the rope.

Derrick Foundations.—It is very important that the derrick rest on a good foundation and be so braced that there is no danger of its slipping. The operators must also have good footing.

Each end of the mast of a boom derrick must be anchored in such a way that there will be no chance of its moving or getting out of plumb.

In the case of guyed derricks it is a common construction at the spider head to have a shackle and link between the thimble of the guy and the spider head. It is the practice of some of the best engineers to require a piece of wire cable to be run around the masthead and through the thimbles of the guys. Use two turns if the size of the thimbles will permit. Fasten the ends of the encircling cable by not less than three clamps. If either the shackle, the link, or the spider should break this cable will hold the guy. It has in some cases prevented the fall of the derrick.

Close attention must be given to the anchoring of the foot of the mast. The tendency to slip at the foot increases greatly as the boom nears the horizontal. This tendency to slip also increases directly with the load.

When the Day's Work Is Finished.—The boom should be lowered to the horizontal or raised to the vertical before leaving at night, so there will be no danger of its swinging with the wind or being meddled with by curious persons when none of the workmen are around.

This should be done by a competent person who has had experience as a derrick man or rigger. All parts of hoists must be inspected at least every other day and moving parts thoroughly lubricated. Slow-moving parts under heavy load are very liable to cut unless regularly lubricated with suitable lubricant. A good graphite grease is suggested. The ropes should be watched for signs of wear. A weakness will usually show by broken wires or twine before the rope breaks.

Sheave pins work under excessive unit load and are particularly liable to wear because of the sand and grit that is almost invariably present on a construction job. The pulleys that may be at inconvenient locations must not be overlooked. All must be inspected and lubricated at regular and frequent intervals.

The Hoisting Rope.—Do not use cheap rope in hoisting.

In the use of wire rope improperly connected trouble is often experienced by the fall having a tendency to rotate and twist the ropes together, which causes serious wear on the ropes and increased strain on the whole hoisting mechanism. Instead of an effort to prevent this twisting by a rope attached to the fall and held by a workman it is better to disconnect the cable and unwind it in a direction contrary to that in which the twist occurs. A few minutes' time spent in correcting the trouble will save much time and wear and greatly increase the efficiency of the work by removing cause for mental irritation of the operators of the derrick.

Wire rope must not be kinked. If a kink is formed it must not be pulled, but should be straightened out carefully. A kink in a wire rope has the same injurious effect as a kink in a wire. When it is straightened out after being pulled, the rope is very much weakened. Wire rope in comparatively short lengths is shipped in coils. Longer lengths are shipped on reels or spools. If in a coil, it should be uncoiled by rolling the coil like a hoop along the floor and letting the free end stretch out without kinks. If the rope is on a reel, the reel should be mounted so it can turn and the rope pulled off. If this can not be done, the rope must be untwisted so as to take out the kinks before these are pulled so as to form short bends.

Safety Measures for Gears, Boilers, Etc.—All exposed gears must be effectively covered, and revolving set screws, keys, or keyways must be protected so there is no chance of clothing being caught by them.

Revolving or reciprocating parts should be covered or effectively guarded, particularly on the side of the engine where the operator stands. The engineer should be provided with a good footing that is not slippery.

The use of steam boilers always involves risks. A portable boiler of a type usually used with a hoisting engine is more liable to abuse and deterioration than stationary boilers and should be carefully inspected. The types usually used are internal fire box boilers of small size, usually vertical. The boiler is called on for full load for a few minutes and then perhaps no load for some time. The engineer, who is usually also the fireman, regulates the steam pressure by opening the fire door to check the fire. This causes a rush of cold air onto the hot sheets which results in severe strain.

The nature of the water used in a steam boiler has a great deal to do with the safety of operation. On construction work it is the custom to use whatever water is available. Many times oil, cement, grit, and other waste finds its way into the boiler with resulting injury. The use of a good strainer and reasonable care in the selection of feed water would largely prevent this hazard.

On the small boilers of most contractors no attention is paid to protecting the gauge glass which indicates the water level. There are a number of cases where engineers have lost their sight; and others where persons have been seriously scalded and even killed as a result of the gauge glass breaking. There are numerous satisfactory safety devices on the market which protect against such accidents. Something should be provided to eliminate this hazard.

The small size of the boiler prevents hand-holes of sufficient size through which the boiler may be easily cleaned and inspected Scale and dirt collect in the water-leg and on the crown sheet with the resulting danger of burned fire box sheets.

The Personal Factor.—Careful inspection and intelligent men in charge are the best ways of securing safety.

The hoisting engineer should be a reliable man who is an expert in handling the hoist. On his ability depends the safety of the workmen and, to a large extent, the speed of the work. This is a poor place to economize. A poor hoisting engineer may easily cause a loss of many times his salary by delay of the work as well as danger to the workmen.

Low Cost Concrete Houses in Industrial Development

Concrete houses cast in place, using standardized forms, built for the housing development at Union, N. J., by the Ingersoll-Rand Co., cost, according to "Concrete in Architecture and Engineering," from which the following details are taken, about $2,000 each for material and labor. The houses contain four rooms, bath and cellar. The first floor consists of living room, kitchen, pantry and a small entrance hall. The second floor has two bedrooms, a bath with open plumbing, two clothes closets and a small stair hall. The house is electric lighted. Exterior is stuccoed. and the inside face of all exterior walls is painted with a waterproof paint and furred with wood lath and plaster, an air space in the wall being thus provided. Inside partitions and ceilings have one thin coat of plaster directly on the concrete. The floor is pine on wood sleepers which in turn are nailed to wood blocks embedded in the concrete. Basement walls are 8 ins. thick, upper walls 6 ins. Floors are 3 ins. thick between beams which are 8 ins. deep, and spaced 3 ft. apart. Each house requires 65 cu. yd. of concrete and 1,000 lbs. of reinforcing steel. Outside dimensions are 16 ft. by 24 ft. 6 ins.

These houses were built by trained crews of about ten men. When the work at Union, N. J., was first undertaken on a large scale, a crew was trained and the work was standardized as actual progress indicated where improvement could be made. Men from this first crew were then selected as foremen for other crews. Certain parts of the work were assigned to certain men who thus became more and more proficient as they accumulated experience. The construction, of course, was progressive so that at a given instant a number of houses were in various stages of completion. Complete data are available on the first twelve houses constructed at Union, from which it appears that the average cost per house was $965.66 for labor and $997.36 for material, or a total cost of $1,963.02. The average time was about 1,500 labor-hours per house, which is equivalent to about 19 days for a full crew of 10 men working 8 hours a day. On the three principal operations, concreting, erecting forms and wrecking forms, the average labor-hours were 199, 235 and 199, respectively.

Why West Point Graduates "Get Along" in Civil Life.—The proportion of the alumni of West Point going into civil life who have filled high stations in civil life in our country is greater than that of any other institution in our country. The following explanation of this fact is given by Maj. Gen. William M. Black in an address before the Society for the Promotion of Engineering Education. "It certainly is not a broad education that West Point gives. Nobody claims that. It certainly is true that cadets do not get a thorough understanding of all that is taught, and I could make other confessions. But West Point must do something or it could not give the results it is giving to the country. And what is that something? I think we could sum it up easily. It is, first of all, that there is inculcated in the young man there the idea of duty, that when a thing is to be done it must be done. It doesn't make any difference whether you want to do it or don't want to do it; it doesn't make any difference whether you think you cannot do it; you have to do it, and that is the first thing that is pushed into them and pushed into them for four years."

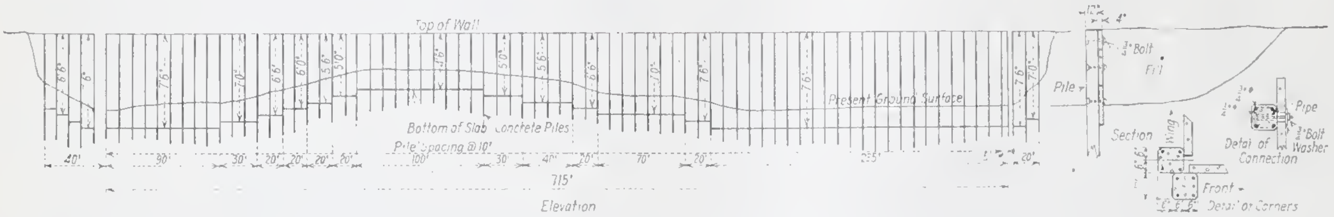
A Low Cost Concrete Bulkhead

By HUNLEY ABBOTT.

A reinforced concrete bulkhead which cost less than creosoted timber construction has recently been built on Hampton Roads, near Newport News, Va. This economy resulted chiefly from the novelty and simplicity of the concrete bulkhead design.

Some residential property which was being developed required about 715 ft. of bulkhead along the waterfront with wings returning to the shore at each end. The top of the bulkhead was to be 6 ft. above low tide and the height of the bulkhead varied from 3 to 6 ft. above the ground line, most of it being 6 ft. high. The soil was compact sand and firm clay. Dredged fill was to be pumped in behind the bulkhead to make land. The bulkhead retained this dredged fill and also acted to some extent as a breakwater.

The bulkhead was built by driving a line of concrete piles on 10 ft. centers and placing back of these piles a series of reinforced concrete slabs which spanned from pile to pile. These slabs extended from the top of the concrete piles down to a depth of 2 to 3 ft. below the natural surface of the in the upper portion and the slabs were held in place by bolts through these pipe sleeves and large plate washers in the inside of the wall.

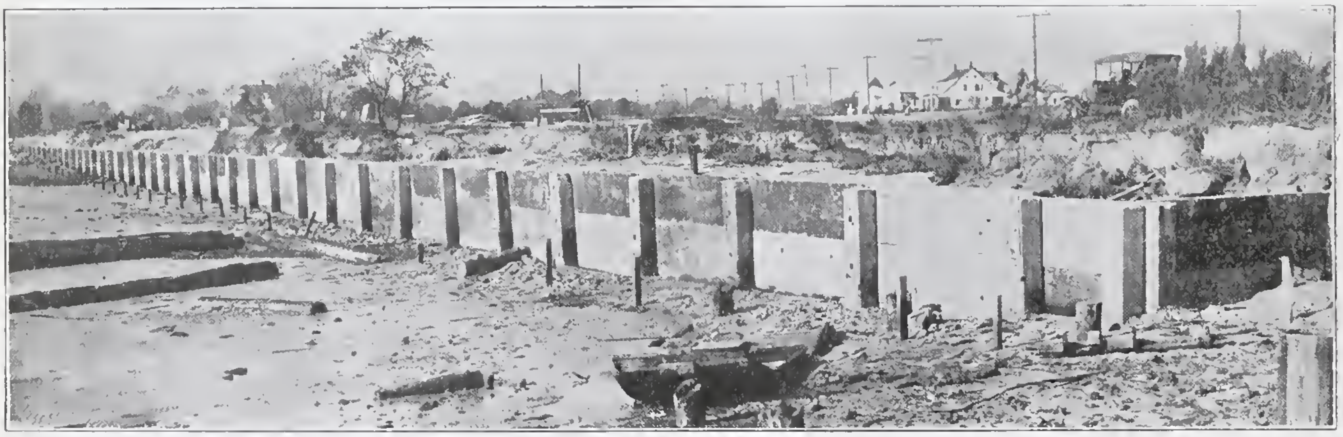


Elevation, Section and Details of Concrete Bulkhead.

The concrete piles were 12 in. square and 18 ft. long and were reinforced with four ¾ in. round rods. When they had cured for 30 days they were dragged to position and driven 12 ft. into the ground by a land pile driver.

The slabs were molded along with the piles. They were 4 in. thick, 9 ft. 8 ins. long and varied in width from 2 to 3 ft. They were reinforced with ½ in. round rods on 3, 4 and 6 in. centers, depending on the position of the slab in the wall. The slabs were placed three high to form the back of the wall, the lowest one being placed in a trench to secure a certain depth below natural ground level.

No anchorage system was provided for this low bulkhead since the concrete piles driven 12 ft. into the firm soil were considered strong enough to resist the earth pressures. During driving, however, a soft spot was encountered at one end of the bulkhead and some of the concrete piles were tied back to wooden anchor piles by ¾ in. tie rods. These tie rods passed through the pipe sleeves in the concrete pile and by placing the plate washer on the rod, it acted as a support of the slab edges in addition to its function as a tie rod. The bolts and tie rods were counter sunk in the outer face of the concrete piles and these counter sunk holes pointed up with rich mortar to prevent rust and to give a better appearance to the finished structure.



Front View of Bulkhead at Very Low Tide.

It should be borne in mind that this type of construction can only be used where firm soil exists at or near the surface of the ground. Otherwise, the fill will press down and force soft mud under the bottom of the slabs. Where conditions justify its use, however, it makes an absolutely permanent bulkhead at very low expense. The following detail job costs may be of interest.

Pile forms (used once) 15 ct. per square foot of covered area. (Piles cast in two tiers with tar paper between.)

Slab forms (used once) 10 ct. per square foot of covered area. (Slabs cast in three tiers with tar paper between.)

Concrete piles, complete but not driven, $1.40 per lin. ft.

Concrete slabs, complete but not placed, 50 ct. per sq. ft.

The total actual cost of the bulkhead was between $8 and $10 per running foot. This included everything but the dredged fill.

The design was made and the work supervised by the writer for Alsop & Peirce, contractors, Newport News, Va.

Rear View of Bulkhead at Very Low Tide.

Annual Meeting of Levee and Drainage Contractors' Association.—The third annual meeting of this association will be held Dec. 30 at the Planters Hotel, St. Louis, Mo. The meeting will be addressed by several prominent speakers on questions of vital importance to the members of this association and to all concerned with drainage and levee work.—C. S. Gannon, 421 Bank of Commerce Bldg., St. Louis, Mo., is Secretary.

Training the Architect by Direct Method

Suggestive comments upon the direct methods of education as applied to the study of architecture, as followed in the A. E. F. schools of architecture, first at Le Mans and later at the A. E. F. University, Beaune, Côte d'Or, are given by Mr. Ernest Coxhead in a recent issue of The Journal of the American Institute of Architects. The suggestions relate chiefly to those methods applied in the training of the architect, which are supposed to fit him for the supreme service as an architect of creative and constructive ability, and in no way is it intended that they should influence other courses of training which are necessary to fit an architect for general practice, such as draughtsmanship, specification writing, theory, history, engineering, business conduct or other requirements.

The following is abstracted from Mr. Coxhead's article:

The direct method, as applied to training for architecture or "field work," as it was named in the overseas schools referred to, should, by its clear-cut advantages to the student, require only to be understood to be advocated, adopted and insisted upon as a major course of the student's career from its commencement in the freshman year. Instead of this, "field work" is at present generally prescribed for students toward the end or after the completion of the 4-year school course and for those who have the means and inclination for a supplemental overseas study trip.

While Europe, with its centuries of accumulated architectural treasures, affords the richest field for the study of architecture of the past and the traditions upon which we must build our ideas for the future development of architecture, after we have brushed away sentimentality, there remains as the chief asset of a course of overseas "field work" the stimulating power to visualize and interpret in terms of scale, proportion, sense of masonry, our own conceptions before transferring them to paper. Again the power to visualize architecture is not to be developed to any extent merely by seeing things, or by gaining fleeting impressions, but by observation, focused and concentrated upon the object in general, and in detail, by actual contact with the building and by means of measured drawings and sketches and notes, further impressing upon the mind the observations made.

The essence of the direct method then lies in taking the student to architecture and confronting him with it in three dimensions, life-size, as opposed to the atelier method of focusing his attention upon mere documentary representation of the actual building.

In the latter case his sense of scale is undeveloped, his ideas of proportion remain distorted, and, by laborious mental effort, he sometimes is able to construct in his mind from the documentary study of plan, elevation, and section what the subject of study, or something akin to it, is in the reality.

The direct method is a reversal of this indirect method of architectural study. In the first instance, the student is taken to architecture; in the latter, he is referred to paper representation of architecture.

The question immediately arises as to how, in a country where architecture has little or none of the background of tradition found in Europe, we can incorporate, with profit, such a method of training in our schools of architecture, to any great extent or even in a supplementary way. The answer should be that tradition is something to be noted but not bound by. It records the logical course of events in the history of architecture, but after all, the important thing to the student of the art is to train his mind on logical consruction, criticism of design, and the placing of ornament and to visualize these things by the most effective and expeditious methods available, using the opportunities nearest at hand for the purpose—whether overseas or in our own country.

The thought here is to show that "field work"—the direct method of training students of architecture—is available for use in our schools without crossing the seas. In our larger cities, especially in the East, there are many examples of contemporary work of unquestioned merit as to architectural design and esthetic excellence, and these, having withstood the depreciating and critical test of decades of time, may be acclaimed as to authorship to be the product of an epoch, rather than the individual mind, and so have come to acquire that impersonal character which fascinates the student overseas and downs superficial criticism and prejudices. This fact then furnishes us with sufficient material to warrant home training by the direct method.

Further, the principle of direct training as related to design, having been once established, should be made an important feature in the student's course, as also related to the fabrication and construction of everything contributing to structural problems of building.

Colleges of architecture, by the impersonality of these institutions, can sometimes obtain privileges for student bodies to visit buildings under construction or completed, private or public, or gardens, or machine shops where the individual might, without this authority, be refused access for inspection or "field work."

In further advocacy of the method, take the concrete example of two students each having a problem for study—a column of cornice. Student A finds a column in a building which pleases him, or is directed to one, and, equipped with measuring-lines, draughting material, proceeds to reproduce it on paper from the actual live model. By this process he has visualized without much mental effort, its shape, dimensions and proportions, and his graphic notes are further aids to memorize the parts. He has sensed the weight, texture, and functions of the column simultaneously. Further, if he has sketched the column, his knowledge of perspective has been developed. In the case of B, he has reproduced a reduced documentary representation of a column with plan, elevation, and section, further developing the drawing by casting shadows accurately, all with the same idea and purpose of Student A, namely, to visualize the functions and characteristics of a column. While B may, by laborious mental effort, finally visualize the columns in a limited sense, and has perhaps produced a more beautiful drawing, A will certainly have sensed architecture to a greater extent at least than B, and this is what the student is training for.

Without further enlargement as to the possibilities of such training if put into operation, the experiment of training by direct method as conducted overseas has at least the sanction of the great master architects of old, whose methods of training and study must have been largely in accord with what is here suggested as the logical process to produce the best work and so raise the standards of architecture.

We have heard a great deal recently about ways of increasing the architect's service to his client. Our school curricula has been expanded and enlarged to train students in business and technical subjects having the enhancement of the architect's service in view. To this end new methods and systems have been adopted, new courses added to every phase of architectural study, with the idea of more efficient service. Is there to be no consideration given for improvements of methods now in general use by students applying themselves to the study of design, and with the same object in view, of effectually rendering the services of the architect more necessary and of greater value to the commonwealth?

Effect of Vibration in Structures.—Four years ago the Aberthaw Construction Co. started an investigation on the vibration of buildings, particularly manufacturing buildings. The study was intended to cover not only the causes of vibration, but also the effects on the structure, on the machinery installed, on the health and well being of the workers, and on the quantity and quality of production. A preliminary report was published in the fall of 1916; but our entry into the war, and the many new problems which that brought, put a summary stop to the work. It is now being taken up again with the idea of following it through to a point where a complete report can be published. The Aberthaw Construction Co. will therefore be glad to have engineers, manufacturers, and others having knowledge of the subject, or having had specific experiences which would throw light on any of its phases, communicate with the company at 27 School St., Boston. The previous work on this problem showed a wide diversity of opinion on some of its angles. It also developed that there is very little quantitative information extant which can be relied upon as giving authoritative data. It is particularly desired, therefore, that information of this character, however limited in its application, may be made available for the study.

Cost Plus Contract Form of Bent Brothers

A cost plus contract under which much large work has been done with entire satisfaction to owner and contractor is given below. This contract was developed by Bent Brothers of Los Angeles, Cal. Regarding it Mr. Arthur Bent states in a recent News Letter of the Associated General Contractors of America: "We find owners quite willing to give us half of any saving we make after the estimated cost has been established at what they consider a fair figure. And we also find it easy to stimulate our employes by saying to them, 'every time you waste a dollar it costs us 50 cts. and hurts our future chances, too.' We have achieved some of our record low-costs on concrete work under this form of contract with the further factor of a share of the bonus distributed to the head men. We do not find profit sharing very feasible or satisfactory, but bonus sharing is entirely so and is also thoroughly logical."

The provisions covering the contractor's compensation under the contract form developed by Bent Brothers are as follows:

Whereas, The party of the first part is about to construct ....

Whereas, The party of the first part desires to employ the parties of the second part as Constructor to supervise and have charge of the above mentioned work.

Therefore, for and in consideration of the mutual promises hereinafter contained, it is hereby agreed between the parties hereto as follows:

Bent Brothers shall hereinafter be referred to as the Constructor.

The Constructor agrees that the estimated cost of the said work is .... Dollars ($..........), which shall be termed the Constructor's estimated cost.

Said Constructor's estimated cost is based upon certain unit prices, among which are the following: (Note that no attempt is made to give more than the few principal items whose fluctuation would seriously affect the cost.)

It is agreed that the Constructor's estimated cost of $.......... may be increased or reduced by the increase or decrease in price of one or more of the above items, and in such case, such new amount shall be the Constructor's estimated cost for the purpose of computing his fee.

The Constructor shall receive for his services a fee to be known as the Constructor's fee, which shall be determined as follows:

If the actual cost of the work is equal to the Constructor's estimated cost, the Constructor shall be paid .... per cent (........) thereof, which shall be known as the Constructor's estimated fee. If the actual cost of the work is less than the Constructor's estimated cost, the Constructor shall be paid the above Constructor's estimated fee, and in addition thereto one-half of the amount which the actual cost of the work is less than the Constructor's estimated cost. If the actual cost of the work is more than the Constructor's estimated cost, the Constructor shall be paid the Constructor's estimated fee less one-half of the amount which the actual cost of the work is in excess of the Constructor's estimated cost, except that in no event shall the Constructor be paid less than one-third of the Constructor's estimated fee.

The Constructor herewith submits a detailed written statement (Exhibit "A") of the principal plant, machinery and equipment proposed for use and the estimated cost thereof, and information as to within what dates the plant and equipment can probably be put to use.

The actual cost of the work shall include the actual net expenditures of the Constructor in the performance of the work, included in which are the following items:

(a) The cost of all plant and equipment used for the work, whether purchased or rented.

(b) All materials and supplies, and hand tools purchased for the work.

(c) All wages and salaries paid laborers, mechanics, watchmen, general foremen, superintendents and all other employes actually engaged on the work, and all rental of teams and motor trucks.

(d) Premiums on employers' liability, on fire and all other insurance, and such losses and expense as are not compensated by insurance or otherwise, as found to have been actually sustained, including settlements made with the written approval and consent of the owner by the Constructor in connection with the work, such as clearly result from causes other than the fault and neglect of the Constructor.

(e) Transportation and legitimate expenses involved in procuring and bringing labor, mechanics or other employes to or from the work and in expediting the production and transportation of material and equipment. Freight and other transportation charges, transportation and expenses of the Constructor or his representatives to or from the work, or auto mileage for same at six cents (6 ct.) per mile.

PLANT: The Constructor shall use his best judgment as to the character and quantity of plant required from time to time for the work, and shall at any time upon request of the owner furnish a statement of any equipment he proposes to buy or hire, and the price thereof.

PROFIT FEE: The profit fee paid the Constructor shall be deemed to cover and include the Constructor's profit, the benefit of his organization, his skill and energy, his administrative expenses, his legal expenses, and all expense of any office or offices of his other than the field office on the work.

PURCHASE AND SALE OF MATERIALS: All materials and supplies used by the Constructor shall be purchased by the owner upon requisitions approved by the Engineer. The Constructor upon demand of the Engineer shall furnish schedules of the materials necessary for the work from time to time and the prices at which the Constructor can purchase such materials.

All materials, supplies, plant and tools which have been included under actual cost of the work and which are on hand upon completion of the work and which have not been rented, shall be sold within ninety days from the completion of the work and the amount derived from such salvage shall be applied to reduce the actual cost of the work. The Constructor, however, shall be given first option to purchase any or all of said materials, supplies, plant and tools at such prices as are obtainable for same.

DELAYS AND CHANGES: In case the owner shall delay the work or in any way increase its cost by change of design or otherwise, such increased cost shall be added to the Constructor's estimated cost as a new basis for computing the profit fee.

1920 Wage Scale in New York Building Trades

Under an agreement entered into early this month by the employers and employes in the building trades of New York City, the 1920 wage scale for various classes of labor will be as follows:

	Per 8-hour day.
Asbestos workers and insulators	$8.00
Art glass workers	7.00
Carpenters	8.00
Cement masons	8.00
Composition roofers and waterproofers	$7.00 and 7.50
Dock builders	7.50
Electrical workers	8.00
Electrical workers' helpers	4.50
Elevator constructors	8.00
Elevator constructors' helpers	6.00
Hoisting engineers (weekly, $46.50); broken time	9.00
Hoisting engineers on combination machinery	16.00
House shorers and sheathpilers	7.50
Housesmiths and bridgemen	8.00
Housesmiths' finishers	8.00
Housesmiths' helpers	6.00
Marble carvers (April 1, 1920)	9.00
Marble cutters and setters (April 1, 1920)	8.00
Marble polishers, bed rubbers and sawyers (April 1, 1920)	7.50
Marble cutters' helpers	6.00
Mosaic and terrazzo workers	7.00
Painters and decorators	8.00
Plasterers	8.50
Plasterers' helpers	6.00
Plumbers and gas fitters	8.00
Roofers and sheet metal workers	8.00
Steam and hot water fitters	8.00
Steam and hot water fitters' helpers	6.00
Tile layers	8.00
Tile layers' helpers	6.00
Upholsterers	9.25

The agreement calls for a working week of 44 hours. It also provides for a permanent board of arbitration, which shall consist of five members of the executive committee of the board of governors of the Building Trades Employers' Association and five members of the executive committee of the Building Trades Council, to whom shall be referred all disputes that may arise relative to alleged violations of the agreement, or the intent and meaning of any part thereof. The decision of the board of arbitration is to be final, and if the board fails to agree after three consecutive daily meetings, they shall select an umpire, whose decision shall be final and binding on all parties to the agreement.

90-ft. Piles for Canadian Dock.—Piles 50 ft. to 90 ft. in length are being used by the J. G. White Engineering Corp. in the construction of a 1,190-ft. long pile dock at Port Alfred, Que. The penetration is from 35 ft. to 40 ft.

Recognition and Remuneration of the Engineer

The joint committee of the technical organizations of Canada has recently formulated an act for the registration of engineers. In connection with this proposed bill the status committee submitted an interesting report discussing the need for legislation. The matter following is abstracted from this report.

The phrase, "Status of the Engineer," may be roughly defined as the reputation and degree of prestige which the engineer enjoys or deserves in the eyes of his fellow-citizens, having due regard to the value of his services to the public at large. Status involves two essential factors: First, recognition of engineering as an essential profession, through the agency of both public sentiment and legal enactment; and, second, an adequate scale of remuneration for services, as compared with other professions and with trades. These two factors may be shortly defined as "recognition" and "remuneration." In handling the above two phases of this problem it is necessary to determine whether they are of equal importance, or whether one takes precedence over the other, and, finally, if the latter is the case, to fix the order of precedence.

Engineering Service a Commodity.—The argument under this head can be conveniently established by analogy. From the bald standpoint of remuneration, engineering service is just as properly a commodity as manual labor, and the revenue derived from its sale is governed first by the number of purchasers who need it, or think they need it, and second, by the amount of such commodity the individual purchaser can be prevailed upon to absorb in place of some other commodity which he has used previously in place of it. There is no virgin market for engineering services. It must compete in long-established markets with other commodities which it must supplement or displace.

The organization of the trade union was essentially an expedient to advertise the worth and importance of a commodity which, for lack of a better term, may be called "manual labor." The unity of interest created by such organizations enabled the manual worker to make use of the strike as an additional advertising expedient, and as a result of the forced recognition thereby realized, he was able to demand a higher price for the commodity he produced, and by the sale of which he existed.

There was no virgin market for shredded wheat. A carefully planned and extensive advertising campaign was instituted to prevail upon the public to eat shredded wheat instead of oatmeal porridge. Through this expedient recognition of shredded wheat was grafted on the public mind. It was educated to think it needed shredded wheat, and thereafter remuneration accrued to the Shredded Wheat Co., with resulting prosperity.

Whether the commodity is "manual labor" or whether it is "shredded wheat," it must be recognized before it can be sold. The greater the public need, whether fundamental, as in the case of manual labor, or cultivated, an in the case of shredded wheat, the greater and more certain will be the remuneration.

Recognition the Precursor of Remuneration.—Considered from the non-aesthetic standpoint as a commodity, engineering service must conform to the same economic laws, and recognition must of necessity be the precursor of remuneration. This proposition would seem to be amply vindicated by the fact that it applies to any individual consultant who has a large clientele, and who can demand a large fee for his services. Almost invariably it will be found that such a man has demanded a higher price for his services as their value became more fully recognized and established. He first obtained recognition through the medium of some form of advertising, which educated an ever-increasing body of the public to need him, or think they needed him, and remuneration followed as a matter of course.

The problem of establishing the status of the engineer therefore resolves itself essentially into devising some means of applying to engineers as a class the laws which have operated successfully in the case of the engineer as an individual. In other words, engineering service generally must have recognition commensurate with its value to the community at large before adequate remuneration can be obtained for engineers as a class.

If, therefore, the engineer is to take the place in the community to which he is entitled by virtue of his attainments and the high class of service he can render, the primary requirement is recognition.

Recognition is obtainable by two general methods, more or less distinct—namely, by general publicity and by legislation.

How to Obtain Publicity for the Engineering Profession.—The ordinary means of obtaining publicity for the engineering profession are many and diverse. The outstanding requirement under this head is for engineers as a class to participate in the affairs of national and provincial government. This contention is so fundamentally sound and has been so often repeated, and so generally recognized, that it is not necessary to enlarge upon it. It is true beyond the possibility of argument that the status of the engineer as related to national affairs cannot be advanced or conserved unless engineers themselves exercise active governmental functions, and pass, as well as frame, the laws relating to or incidentally affecting the profession. The civil service bill now before the Dominion house is a luminous exemplification of this condition. This bill is of vital importance as related to the status of engineers as a class. It seeks to give engineers in the civil service a professional status as distinguished from the status of the ordinary departmental clerk, and also to establish an advanced salary scale. It has been framed with the assistance of engineers, but it is fairly safe to say that there is not a single practising engineer in the House of Commons to argue and support the passing of this bill. Its very doubtful fate rests mainly in the hands of lawyers, doctors and farmers. The probable opposition and non-support of such men cannot be charged so much to active enmity as to excusable ignorance and lack of interest, for which condition engineers themselves are mainly responsible.

Among other channels of publicity may be mentioned the active participation of engineers in town planning, housing and settlement problems, and in developing such problems into specific schemes for government ratification and administration. Conditions governing publicity in the broad sense demand that engineers must seek out and identify themselves with all beneficent movements and projects, particularly those which have a wide public appeal.

Finally, there comes the question of unionism as a means of obtaining recognition through publicity. The various technical organizations of this country could assume the essential functions of a trade union if their constitutions were so amended as to permit them to adopt the principle of collective bargaining and to promulgate strikes. This method of obtaining recognition is without doubt repugnant to the majority of engineers, and, while some transitory benefit might be derived by junior engineers, the general effect would be a very material lowering of the status of the engineer in his own estimation, and in the estimation of the public from whom he derives sustenance. It is difficult to conceive of a town manager, a commissioner of works or a consulting engineer participating in a strike, or to imagine that the diverse, and at the same time interlocking, activities of engineers could be so grouped and segregated as to render them susceptible to the principle of collective bargaining. The proper sphere of activity for any man who wishes to use collective bargaining and the strike as an economic weapon is in a trade, and not in a profession. The value of creative engineering work and the work incidental to the solution of engineering problems in general must be appraised on an individualistic and not on a collective basis. Unionism does not therefore appear to be a proper medium of publicity for engineers to employ as a means of obtaining recognition.

The other factor involved in the problem of recognition is legislation. In its relation to the matter of recognition, legislation should be considered as a defensive weapon, as distinguished from publicity, an offensive weapon. In other words, publicity should be the sword, and legislation the shield, of the engineering profession.

Canal Reconstruction in France.—Out of a total of 228 miles of canals or rivers rendered unnavigable at the date of the armistice, only 62 miles remained unserviceable on Nov. 1, 1919, and on a considerable part of these navigation is possible with light-draft vessels. It is expected that the greater part will be ready for service by the end of the present year.

Standardization in Construction

Although, according to P. B. McDonald,[*] the craze for standardizing everything that possibly could be standardized reached its high point in Taylor's efficiency engineering, there still seems to be room for more of it. Ernest T. Trigg, President of the National Federation of Construction Industries, in an address before the Engineers Club of Philadelphia, points out a number of things and methods in construction that may, with profit, be "standardized." The following notes are taken from his address:

The arguments for standardization are summed up as follows:

1. It permits of manufacture on a quantity basis.
2. It makes it possible to produce a supply during the slack season, thereby tending to prevent seasonal employment, decreasing labor turnover and facilitating prompt delivery.
3. It reduces maintenance cost and makes repair easier.
4. It eliminates poor design and unsatisfactory supplies.
5. It reduces the labor and machine costs, both at the factory and at the site of erection.
6. It makes possible closer co-operation between architects and engineers and the men who produce, distribute and install material and equipment.
7. It assures a uniform degree of safety and efficiency during and after construction.

In a word, a properly executed program of standardization in the construction industry appears to point the way to a better service, from the standpoint of both the construction interests and the consumer, and to reduced cost.

Arguments against standardization are:

1. It limits efforts to make pleasing designs.
2. It limits choice.

In answer to the objection that it limits efforts to make pleasing designs, it might be said that standardization applies more to the constituent parts of building than to the whole. It seems unlikely that standardization would ever be carried to the point of limiting pleasing designs for buildings.

Regarding the matter of standardization limiting choice, so long as standardization eliminates only the bad, the unnecessary, and the superfluous, choice in the real sense of the term is not limited. It is quite likely, no matter how far standardization may ever go, that there will be people in the world who will want to pay the price for excessive individuality, and it is just as likely that it will continue to be for sale.

Plumbing, screw threads, pipe and pipe fittings have been more or less standardized. Engineering societies have done a great deal toward standardization of specifications for cement, steel, alloys, and other materials of construction, but Mr. Trigg suggests further progress along the following lines:

Engineering Standards.—These including chemical and physical compositions of raw materials and technical dimensions, illustrated by the work already done on screw threads, etc. Such engineering standards in many cases have already been developed through the work of the engineering societies.

Commercial Standards.—In this field much less has been done than with engineering standards, and it is here that a widely representative commercial organization, rather than a professional or technical society, must take the lead.

There are many matters along this line claiming the attention of the construction industry at this time, and a few examples of which are given below:

Freight Elevators.—At present freight elevator manufacturers are making about 33 different kinds of freight elevators; some models vary from others only in inches or fractions of inches and have but slight differences in speed. The manufacturers say that a much smaller number of types will fill all commercial requirements. If freight elevators are standardized, the manufacturers can keep their factories running and build up a stock, whereas now they tend to custom-build the elevators to order; and the elevators can be secured in less time at smaller cost.

Slate Slabs.—There is said to be a need for establishing standard sizes of slate slabs for structural purposes and also for a better general understanding of the slate industry so as to prevent specifying "clear" (that is, free from veins and ribbons) because only about 20 per cent of slate slabs can possibly be cut "clear." The adoption of standard sizes of slate slabs for structural purposes would permit slate manufacturers to operate at full capacity during the working season and therefore to supply builders without delay during the entire rush season of building erection.

Concrete Culvert Pipe.—The construction of both railroads and highways is intimately tied up with and, to a large extent, dependent upon the standardization of concrete culvert pipe, which is now being worked out through the combined effort of a number of engineering and commercial organizations.

Tile.—D. Knickerbacker Boyd in "The Architectural Forum" for July says. "No one who has not actually visited a tile plant and kilns can begin to realize the enormous amount of handwork, burning, handling and sorting which is bestowed upon the regulation of white tile, which when finally in the wall or on the floor has such a machine made and uniform appearance.

"One cannot but wonder when viewing the large force of people sorting tile why the slight variations in shade, said by some to be over 40, should not be taken advantage of on the score of appearance alone, instead of causing this labor and expense to be put into the process that custom seems to have established as necessary. Does the end justify the means?

"And if it were understood what countless numbers of bases, corners, angles and other parts must be made to accompany each size and shape of tile, the present range of choice in the units comprising a plain white field would be reduced to the rejoicing of all concerned.

"And just as it is impossible to produce all perfect specimens and uniformity of size in any product resulting from concentrated heat, so would the situation be immeasurably helped if so-called firsts, standards and seconds in tile were to be appropriately used. Truly, it is a waste of energy and money to use the best specimen of kiln production in lining an elevator or other shaft or similar features in a building, or portions where light and sanitation are as well served by using the grades remaining after the selection of those more nearly approaching perfection has been made."

Bricks.—Just as in the case of tile, it works an economic hardship for specifications for brick to require their being "of first quality only, free from imperfections, blemishes, defects, etc." One quarter of the brick manufactured would have to be thrown away if only hard burned brick were specified. The question of a standard size for bricks is one that has received much attention. It is difficult to solve, because brick machines get larger from long use and there is a lack of uniformity regarding the effect of burning one size.

Mortars and Joints.—Within certain ranges of climate, mortars and joints should be standardized instead of varying as at present according to individual judgment.

Lumber and Mill Work.—The lumber trade associations have worked out grading rules which have established a number of lumber standards. For finished lumber and particularly for mill work, however, it is said that there is an almost untouched field for standardization. There appears to be real need for standardized doors, windows, trims, mouldings, and built-in-closets, and other furniture of various kinds. A beginning has been made in this work by some manufacturers. Such standardization, including perhaps the completion of the various units at the factory, would eliminate much labor incident to finishing at the point of erection.

It has been suggested that waste products of lumber mills might be worked up into short pieces of standard dimensions for those parts of construction where longer pieces are sawed up into short pieces at the point of erection. This would result not only in a saving of material, but also in the labor employed by the contractor.

A great many other commercial standards, the needs for which have manifested themselves, might be mentioned, but the above rather heterogeneous list will convey an idea both of the extent of the needed standardization and the great diversity of the commercial standards that might be developed.

3. Standards of Business Practice.—Business practice standards sound abstract, while engineering and commercial standards appeal because of their concreteness. It is, however, not an overstatement to say that more business reverses and actual failures have been caused because of the lack of standards in this field than because of a similar lack in any other. Some business practices that would lend themselves to standardization are:

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[*] "The Personal Element," Engineering News-Record, Nov. 6, 1919.

Cost Accounting.—The Saturday Evening Post says, editorially: "Of all the handicaps that retard business success none is more serious than the ignorance of manufacturers in the matter of production costs. The Federal Trade Commission reports that in the United States only 10 per cent of our industrial establishments know what it actually costs them to manufacture their products; 40 per cent simply estimate their costs, and 50 per cent have no method whatever of finding out what their production charges really are. This condition is largely responsible for a national situation where more than one-third of our 300,000 manufacturing industries did not earn 1 per cent on the billions of capital invested in them.

"One of our leading authorities on shop efficiency contends that with correct equipment and proper instruction, the average workman will do at least three times as much as he now does, and can continue to do this greater work month after month. One large automobile manufacturer called on science to modernize his methods, with the result that certain of his costs were reduced two-thirds, with the same product and the same equipment and men. Only the intense application of brains to business will remedy the present situation of decreasing profits and rising costs."

The president of the Associated General Contractors of America, Mr. D. A. Garber, recently said in an address:

"A good friend of mine over in Brooklyn has been a contractor to my knowledge for 30 years, and he has been successful; I don't know how; but I suppose by the grace of God—that is what usually saves most contractors. I asked him how he kept his books. 'Well,' he said, 'that is simple enough. I do it the same way my father did. When I get a job I figure up how much money it is going to require to run that job. If I think $5,000 will do it, I take $5,000 and put it into a new bank. Brooklyn is pretty well supplied with banks. All the money I get from that job I put into that bank account. When the bills come due, I pay them out of that account, and when the job is complete, if I have more than $5,000 in that bank, I know I have made money. If I have less than $5,000, I know I have lost money.'

"You would be surprised," Mr. Garber goes on to say, "to know how many contractors have run their business that way in the past. But now we want to keep our own books. We want to make our own estimates. And we are assured, if a proper system of cost accounting is sent broadcast over the country among contractors, that it will be a universal help to them."

General Accounting.—There has been so much agitation over the country about cost accounting that relatively small attention has been paid to the matter of accounting in general. Perhaps it is because of the lack of a suitable system of cost accounting that a business man's pocketbook is hit first, but cost accounting is just one link in the accounting chain; and it has been urged in some quarters that standardization should include the general field of accounting which might be worked out for any business, so that a balance sheet can be struck, not only once a year, once in six months, or even once a month, but so that any day a business man can see a report showing where he stands that particular day.

Contracts.—The Contract Record for Sept. 17, 1919, says: "A national contract form, accepted and adhered to by all contractors and architects throughout Canada, is the hope of many in the construction industry." All schedules for building work in Scotland follow the plan laid down in The National Building Code of Scotland, which uses quantity surveying methods. All schedules of building work there must adhere to the same conditions and therefore contracts are standardized on the same footing. It is most likely that the American construction industry would benefit through the standardization of contracts.

Standards of Legislation.—From certain quarters has come insistent pressure for standardizing municipal and state building and safety codes, and state inspection legislation, such as that regarding boilers. It is recognized that building codes, for instance, must vary to some extent with regard to different climatic regions. However, uncalled for disparity in regulations in the different cities and states makes it almost impossible for the manufacturer of building equipment to comply with the various legal requirements placed upon him, and similar hardships are worked upon practically all other construction people in much the same way. Undoubtedly legislation in some cities and states in reference to a given subject is superior to that in other localities, and the effort at standardization along legislative lines should be unselfish and designed to enhance the welfare and safety of the public. Legislative standardization would also refer to bonds given by bidders, to other financial relationships, to fire protection and many other matters affecting the construction industry.

Construction standards, in so far as they relate to materials, should invariably be understood as representing minimum requirements that must be complied with rather than the maximum over which no manufacturer may go in respect to quality. Manufacturers need not be asked to deliver up their trade secrets, nor architects their individuality of design; but, if construction standards are to assume real importance in the industry, a truly democratic, co-operative spirit must be manifest.

The Hoist as Aid in Tearing Down Old Buildings

By employing a motor hoist, Villadsen Bros., Inc., engineers and contractors, Salt Lake City, Utah, effected a considerable saving in labor in demolishing old buildings in its Social Hall avenue development in Salt Lake City.

The motor, drum, and cable had been in use as a hoist on the construction of new buildings, and the idea of using it to tear down the old buildings, on the same site, appeared to be worth trying out. It proved very successful.

Motor Hoist Demolishing Old Buildings.

The cable arrangement simply passed through blocks to double its pull and apply the force from the right direction. In the position shown in the illustration the cable was passed between a door and a window, and a moment after the picture was taken the operator threw in his clutch and the whole section of wall on that side collapsed instantly. When studded and lathed partitions were pulled down they were dragged over to the pile, and effectually broken up into easily loaded parts in the process. The motor is 30 hp., three phase, of the squirrel cage type.

Highway Contractors' Conference in Chicago.—The State Highway Department of Illinois has invited all contractors interested in highway work in this state to a conference to be held in the Red Room of the LaSalle Hotel, Chicago, at 10 a. m., Dec. 26. Among the matters to be brought before the meeting are the following. Discussion of features brought out by experiences the past year on the part of the contractors and on the part of the state. The 1920 building construction program. Discussion of the question as to how much work should be attempted. Amount and different kinds of state equipment that may be available. Provisions for utilizing railroad cars in the handling of road building materials during the early part of the season. The question of prices to be paid for labor and materials next year. The question of time limit on the completion of contracts.

Co -Operation Among Engineers*

By Dr. F. H. NEWELL,

President American Association of Engineers.

What does cooperation mean? We have used the word frequently; I have discussed it often and have tried to bring about cooperation among engineering bodies. It means merely a working together effectively. While such working together is theoretically the wise, the most obvious thing to do, practically it is one of the most difficult things to bring about because of the tendency of men and organizations to segregate rather narrowly in order to secure higher efficiency; to work along narrow and narrower lines and to keep clear of all entanglements tending to divert their attention.

Personal Advantages of Cooperation.—Our problem, and the one we wish to discuss this morning is how best we may cooperate and for what reason we should cooperate.

The reason is obvious. It is primarily and fundamentally in order that we as intelligent men, as citizens, may benefit personally. There is no use getting away from that. There is a reasonably and necessary selfishness running through our plans, yet that selfishness, while we recognize it, is not the beginning nor the end of the problem. An intelligently directed selfishness may bring the highest results to the whole community.

All engineers to a certain extent are men of vision, they are idealists, and we can all agree that to put over a successful idea you must have a near as well as a remote object. We might as well admit first as last that we begin primarily with the conception that by cooperation we intend to help ourselves and help our associates. In doing that we are not losing sight of the fact that in helping ourselves we must help the community and the public at large. Moreover anything that helps us but is to the detriment of the public we must not tolerate. I want it clearly understood that while starting with the primary assumption that all incentive to cooperation must be founded upon a desire to help ourselves, yet it must not be developed in such a way as to interfere with our great ideals. It must lead to the best result for the common good. I put this proposition to you frankly because in all our plans we must consider not only what is the immediate good but we must not let anything interfere with the ultimate good of the community as a whole; helping ourselves intelligently and wisely to help the community at large.

How can we do it?

Second Hand Cooperation Not Effective.—The Engineering Council representing the officers of the founder societies is at work as one of the results of these attempts at cooperation, but because of its form of organization it cannot be as effective as a less cumbersome device. It has no power to enforce or carry out its conclusions being simply a council dependent on the good will of the separate societies and on the personality of its agents. We may theorize about the efficiency of different forms of organization, as to how best to organize men; but experience shows that some of these schemes which look well on paper may not work out because they do not appeal to the peculiar spirit of our people.

To illustrate my point, we formerly elected the U. S. Senators by the vote of the state legislatures, but as you know there was a feeling that the Senate thus chosen was not well selected. It was a representative body that was the choice of other representative bodies. This second hand delegation of power never seemed to work right. A similar criticism is made against any council chosen in this way.

Here is perhaps a more striking illustration of how this kind of cooperation does not satisfy. Before the present constitution of the United States was adopted we had a loose confederation of the states; each state voluntarily cooperated or attempted to cooperate with every other state, the result you know was disastrous. By great good fortune the people of the United States were led to adopt the present form of constitution without which we probably never would have existed as a nation. Theoretically the old way of cooperation among states was perhaps ideal, practically it did not work. Under our constitution we are citizens of the United States first, last and all the time. We are not citizens of the United States because we are citizens of Ohio or because we are citizens of Columbus but we are citizens of the United States and elect our representatives directly to the United States Congress.

Similarly, plans for cooperation among engineering societies have not worked out practically where the citizenship or the membership is represented not directly but by a body chosen as the result of a second or third delegation of power. We want the power to go directly from each citizen or member to the responsible parties.

A National Organization of Engineers and Architects.—Because of the recognition of this principle we have started in another form of cooperation; a conclusion reached by going all around the circle, by trying different things and finally reaching this result. Parenthetically I wish to say here that this summer I have spent much time in traveling from the Atlantic to the Pacific, from the Canadian line to Mexico, visiting town after town, talking with engineers in their offices and in their meetings, much as I am talking now, getting acquainted and urging them to cooperate and to get together along the line where every individual man will be represented in a national body not indirectly through a local organization, which in turn delegates its power, but as members of one civic body, engineers and architects, and that is the American Association of Engineers. I hope you will be patient while I exploit this not as the only organization but as the form of organization that I think is going to win. The final outcome may not be in the name of the American Association of Engineers but it will be some form of organization of engineers and architects which working directly will achieve the result to which we are looking forward.

What is it we desire to do? We want to improve the condition of the engineer and the architect. We want to improve his condition financially, mentally, spiritually, as a citizen, as a man and as a member of a group of trained workers. That is why we are trying to cooperate, subordinating the interest of the individual to the interests of all humanity, and yet in our enthusiasm for these higher things, not forgetting that the man down in the ranks must have his fair share and proper treatment if we are going to have a strong organization. That is what we are working to do in our cooperation.

Some will say at once, and this issue should be met squarely, "These advocates of the A. A. E. are attempting to establish a glorified laboring union." In reply I may state that I do not hold any brief for labor unions. They can take care of themselves; they are well able to do so. But I do desire to point out certain differences between the kind of organization needed to secure cooperation among brain workers and the labor unions.

In the first place the American Association of Engineers is an incorporated body. It is a responsible body. It differs from a labor union in that respect because whatever it does, whatever it agrees to are matters for which it is responsible. As you know the prime element of labor unions is irresponsibility. Of course there are all kinds of labor unions, as there are all kinds of churches. With some people labor unionism is a religion. Men have given their lives for the labor union. Many of them have done great and good work, others have not, but the danger today to society exists because these labor unions are irresponsible bodies and cannot be held to any agreement into which they enter.

This is an age of organization.—The unorganized man is not effective in performing his duties or securing his rights nor is he able to preserve the rights of others. The question before us as engineers and architects, brain workers, is not whether we shall organize but as to what kind of organization we shall create. Shall we enter an organization that is incorporated, that is responsible, or shall we continue to organize the small groups of technical men to discussing technical topics and tabooing all the vital questions of society?

A noted preacher recently said, "Some boys go to hell because there is no other place for them to go." Today in the unorganized or disorganized condition among engineers and architects we are forcing men into labor unions because we are not freely admitting them into our specialized societies. The great body of these plain men that I have described as the non-commissioned officers of the army of engineers, the draftsmen, the surveyors, the checkers, these are the men we are forcing into labor unions. That is where my interest lies in this great cooperative movement, namely to get those men organized into a body that is responsible for its acts, a body in which every man feels that responsibility legally as well as morally, and keep them out of the irresponsible labor union that is eagerly seeking them.

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*From an address before the Ohio Association of Technical Societies.

That is the condition we are facing. It is not a theory. It is a fact that unless we do cooperate in a sane, definite businesslike way, meeting the present conditions of society as they are, this is going to come about in a very few years. That is why I am so intensely interested in upbuilding an organization that will keep these men as I have said, in a responsible body led and officered by natural leaders, men to whom they can look with respect.

That is what I mean by ultimate cooperation among engineers and architects. We have worked through and beyond this idea of forming small societies of civil engineers and of mechanical engineers and so on with the idea of then getting them to work together, and somehow out of that same combination produce a powerful organization. This idea does not work under present economic conditions. For efficiency we must have an organization in which every man is a member just as much as he is a citizen of the United States. That does not prevent his being an active citizen or member of his technical society, any more than your citizenship in the United States prevents you from being a good citizen of Ohio or of Columbus. In fact it strengthens it; but the two citizenships are independent and function without any interference with each other.

Production and Compensation.—There is in the world a shortage of all goods, every necessity of life, and the only right thing we can do is to increase production and organize to fight every movement that there is to keep down production, and at the same time accompany that effort by seeing to it that a proper compensation is given to all men who are engaged in that increased production.

How are we going to do it? Are you going to organize a union and call a strike to get more money? We say most emphatically we are not. In the case of men who are thinking, it is not necessary to do that. While so-called capitalistic organizations may organize a lockout or the labor unions may organize a strike, we believe we can accomplish permanent good, not by force or intimidation, but by using the weapons that every intelligent man should use: common sense, argument and reason.

Under present conditions of depreciated currency, where money is worth half or less than half of what it was before the war, and where the value of currency has dropped, the readjustment to meet the altered condition of our standard of value must be met gradually and wisely. And how can it be met? Only by presenting our claims honestly, sincerely and convincingly.

Certain engineers in municipal, public and railroad employ, relatively to the value of money, are getting less than the amount to which they are entitled, less than the amount on which they have been accustomed to live and the amount which they should spend to be good American citizens. The thing to do is to present that fact, without the alternative of threats of going on strike, but as intelligent men, educating the public and the people concerned.

We have followed that course. It is not a question of whether results can be had in that way; they have been attained. Such a course is not as spectacular as it is to call a strike but in the end it accomplishes the result, and it is done in a way that preserves the self-respect of all the men and a proper appreciation of the dignity of their profession.

We must get together in some form of organization, effective primarily for the benefit of these men, but ultimately looking forward to that larger benefit to humanity. On this basis alone can an organization long exist. We cannot survive permanenty if we adopt a low moral plane, if we organize for ourselves excusively; but if we desire to endure and to have the respect of the public and to put the men of education and experience where they belong, the engineers and architects must be organized and their organization founded on deep principles which will benefit the public and the human race.

National Conference on Construction.—The annual meeting of the Associated General Contractors of America and affiliated organizations will be held at Chicago Jan. 21-23. Coincident with the business sessions of the Association, a 2-day national conference on construction problems will be held, to which all general contractors will be invited. The offices of the association are 111 W. Washington St., Chicago.

The Liberal Element in Engineering Education*

By GEARGE F. SWAIN,
Professor of Civil Engineering, Howard University

The question as to the liberal element in engineering education, or a liberal education by itself, arises from a recognition of the fact, that since we live among men, an educated man should have some knowledge outside of his own vocation, of language, literature, history, and economics, so that he may understand and appreciate what goes on about him, that he may know something of the thoughts and deeds of the great men of the past, and may be able to write and to express himself clearly and logically. Without these things, a man may have great skill and knowledge, but not attain his greatest usefulness or development.

Motivation the Key to Effective Instruction.—The difficulty is that in the study of these subjects the student may not be able to relate them to his experience, that is, his work is not motivated, and so he achieves small results. The subject of this paper is mainly motivation, or doing work with a distinct motive, gained by being able to see what is being done, the need and use and application of it, which is only possible, if my view is correct, if it can be related to experience. It is a great fallacy to suppose that a boy will gain what is called culture by listening to courses of lectures, especially if he is not interested in them. Some of the most uncultured men are college graduates.

Few students take much interest in Greek and Latin. Those tongues are dead, and the student does not realize their significance in relation to our own tongue. Modern languages have more interest to him, because he can use them. History may interest him little because it does not deal with the present, and he cannot relate it to the present and coordinate it with his daily life. Economics he may think he can understand, because he hears it talked about so much, but since it deals with business questions in which he has had no experience, he really cannot grasp it concretely or safely. Science, mechanics and engineering he can understand, because he lives in a world of science and engineering, he can relate these to his experience; yet even in these subjects we take pains to relate them to his experience still more closely by providing laboratories. Even this is not always deemed a sufficiently close relation, and we employ the cooperative system, as at Cincinnati, where the pupil alternately sudies and works in a shop and so is, as Mulcaser advises, "a-doing while he is a-learning." Mathematics, in arithmetic, he can relate to his experience, for he has to buy and sell and make change every day; but in its higher branches it is abstract to him, he does not interpret or grasp it, and this is perhaps the reason why so many boys hate it, unless it is taught and used distinctly as a tool in connection with science and engineering, and preferably taught by men who themselves use it in their daily work.

It is of course true that there is such a thing as a stimulus lasting a lifetime derived from a single lecture, a single point of view, a single idea. But such a stimulus may as well be gained from a sermon, an academy lecture or a conversation with a friend. We should not judge a college course on such a basis, except that we should try to have stimulating teachers, who would look beyond the narrow confines of their subjects, deal with the individual student as much as possible, meet students outside the class-room, and try to influence not only their knowledge but their character.

The key to effective instruction, it seems to me, is motivation. Relate the subject to the student's experience. If it cannot be so related effectively, better not teach it. We make a common mistake when we assume that when a subject is put into the curriculum it is put into the student. We cram the curriculum full of every subject of human interest, regardless of whether the student can relate it to his experience. If he does not so relate it he will generally take no interest in it and get nothing out of it. If he does take an interest in it, it will often be by relating it, not to his experience, but to his imagination, and in this case he will get less than nothing out of it; it will do him harm. He will become a theorist who does not care for facts, but only for his imagination and his preconceived ideas.

History and Economics.—Some subjects are difficult to motivate and should not be taught in school. History is often not related, if taught as a barren chronology of facts, but if made live by showing the causes and effects of great events, the tendencies of the times, and illustrated by the characters of great men, it may be one of the most useful of studies. But history cannot be related experimentally in the laboratory. Sometimes, in the laudable effort to motivate, ludicrous and time-consuming methods are resorted to, as when a class in American History was made to "live" their history by building Indian wigwams. In such a subject everything depends upon the teacher and how the subject is taught.

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*From the Bulletin of the Society for the Promotion of Engineering Education.

Economics is difficult to motivate, since it deals with complicated matters of business, not within the range of experience of the student. I have long believed that the excessive teaching of this subject now quite common was not only profitless, but injurious, notwithstanding the intrinsic importance and interest of the subject. The student will frequently find in this subject his own teacher, an eminent man, holding opinions diametrically opposed to those held by an equally eminent teacher at a neighboring college, while neither can be demonstrated to be in error. What a field is here for the cultivation of a dependence upon preconceived ideas, even if contrary to facts! The inherent importance of the subject may enlist the interest of the student, but he cannot relate it to his experience, and so relates it to his imagination or his sympathies. His sentiment is stronger than his reason, and he becomes a faddist, indulging his preconceived ideas at the expense of society. Perhaps no subject depends so much upon having a safe, logical, unemotional teacher, himself experienced in business affairs or capable of seeing them without distortion. One brief course in the subject should suffice to give the student an idea of its scope, methods, and general principles, and an outlook over the problems with which it deals, sufficient to serve as a basis for later study, as he gains experience in the business world.

Training in Science Best for Study of Economics.—A bad teacher of science, or of mathematics, or of engineering may do little good, but he can hardly do positive harm. At the most the student learns nothing from him. But a bad or unbalanced teacher of economics may do positive harm, in inculcating unsound and vicious economic theories into the minds of immature students who have not the experience nor the trained logical minds to discover the errors. The best training for the study of economics, I think, is a training in science, so that demonstration may be distinguished from hypothesis, and truth recognized when found. A subject on which opinions differ widely, while few can be demonsrated to be correct, does not appear to be a good one for an immature and untrained mind, though it may be a very useful subject of study for a mind already trained in logical methods, and with experience as a guide. Personally, I believe that the excessive study of economics in our colleges, and the turning out of large numbers of young men who have "specialized" in this subject, and who go out into the world thinking they know all about these great questions, though totally without practical experience, and without training in scientific methods of investigation as well, is one of the most serious menaces to our country. You cannot experiment by the scientific method in economics, because you cannot vary one element only. There are always many elements, the relative influence of which cannot be measured. After a young man has studied science thoroughly, has learned the scientific method, and has acquired the scientific attitude of mind, it is time for him to study, in detail, the great questions of economics, and not till then.

Some branches of economics may be motivated. One of these is accounting. Every boy keeps, or should keep, a cash account, and the study of double entry book-keeping is not only a means of excellent mental training, and of the principles of accounting, but is eminently practical. The same is true of the elementary parts of other branches. The engineering student should be taught what a bank is and does, how he can use it, the methods of promoting and organizing a business enterprise, the different kinds of securities, and so on. Some topics connected with business management, the methods of securing efficiency, the importance of cost data, may also be taught to advantage. The elements of business law may also be appropriately included.

English and Logic.—One of the best of liberal studies is English, particularly if including a course in Logic. Surely few things are more important to the engineer than the ability to write a good report, and to express himself clearly, forcibly, concisely, and logically. But the course in English should not be the traditional course. It is of little importance to the engineering student whether Keats was a greater poet than Shelly; but if the student is led up to the study of good writers through his own experience in trying to express himself, or by seeing the relation of the subject he reads about to the necessities of his own profession, he will gain an interest heretofore often lacking. Some courses in English are now being conducted in a way to secure this result.

But in recognizing the importance of liberal studies for engineering students, or for any students it may be proper to say a word as to the importance of science, for students of liberal arts and other than scientific professions. Of all studies, the sciences and their applications are probably the best and most useful, as a means of discipline, for their motivation, and for the knowledge and even character that they impart. This has been shown at length by Herbert Spencer in his book on education. The sciences offer all the elements of logical analysis, hypothesis, experiment, verification. They are not rigid, like mathematics, but afford room for doubt, hypothesis and argument. Neither are they vague and incapable of demonstration—mere matters of opinion—like many branches of economics. Moreover, every youth should have disciplined knowledge of the world in which we live and the physical phenomena which he experiences every day. Yet in some of our colleges it is possible for a boy to graduate without taking in college a single course in natural science or in mathematics. If I recognize and urge the importance of liberal studies, and even of the classics, for all broadly cultivated men, I must even more urge the importance of science for every man. I believe that in our colleges we are committing the great mistake of neglecting science in favor of economics, sociology, and literature, which are far inferior in disciplinary value and in power of motivation.

A Method of Securing Profitable Rivalry on Building Contracts

Recently the Aberthaw Construction Co. of Boston, had under simultaneous construction similar contracts at New Britain and at Greenfield. As most of the men in the organizations for both jobs were acquainted, and both had the interests of their employers at heart besides wishing to demonstrate their efficiency, it was decided to keep comparative records of the work and accordingly they were arranged to show graphically the percentage of saving, or excess over the estimated cost of the job and these were conspicuously posted over the superintendent's office where they were always visible to the entire force and stimulated them to extra efforts to outdo each other.

A large bulletin board painted white was provided with a vertical scale graduated from zero to 25 per cent both up and down from the center point. Above the zero point the scale was marked "Saving" and below it was marked "Overrun." On each side of this vertical scale there was arranged a horizontal index or arrow movable in a vertical slot. One of them was marked "Greenfield" and the other was marked "New Britain," corresponding to the two contracts. Every day each arrow was set according to records and indicated by what percentage the cost so far was over or under the estimate. When, as happened during the work, one of the arrows was below the zero point and the other above it, enthusiasm and anxiety ran high and the men made great efforts on the one hand to maintain the lead and on the other to decrease it.

Every workman on the job was personally interested in the competition and it undoubtedly resulted in a considerable saving in total cost on both jobs.

Similar devices could easily be arranged for many kinds of work and the idea could be extended to provide comparative records for different gangs on the same kind of work in the same contract or for all of the different kinds of work on a large contract with perhaps the additional spur of offering a bonus for the gang that showed the greatest "Saving" percentage at the end of the work. Such ideas and variations of them, states the Contract Record, may be made very valuable in justifying the high wages that are now paid and in reducing the unit cost and total cost of construction operations.

Analysis of Concrete Proportioning Theories; Tests All Agree But Interpretations Differ

During the last year and a half Prof. Duff A. Abrams has published his "fineness modulus method" of proportioning a concrete mixture and Lewellyn N. Edwards has done the same for the "surface area method." The Bureau of Standards has apparently contradicted the basic principles of both methods. The periodicals of this country and of Canada have taken up the subject "pro" and "con," but the majority of engineers have been too busy or perhaps the subject has been too controversial, to enable them to take proper sides. Now Mr. Roderick B. Young, Engineer of Materials Laboratory, Hydro-Electric Power Commission of Ontario, gives in The Canadian Engineer of Nov. 27, 1919, a real analysis of the findings of the three investigators and with the aid of additional facts, proves that the tests of each agree but differ only in the interpretations. He gives brief resumes of the three investigations and clearly points out the essentials of each. All of us would be most interested in the method adopted by the Hydro-Electric Power Company and sincerely trust that Mr. Young may see fit to publish the same in the near future. The article referred to is given below almost verbatim:

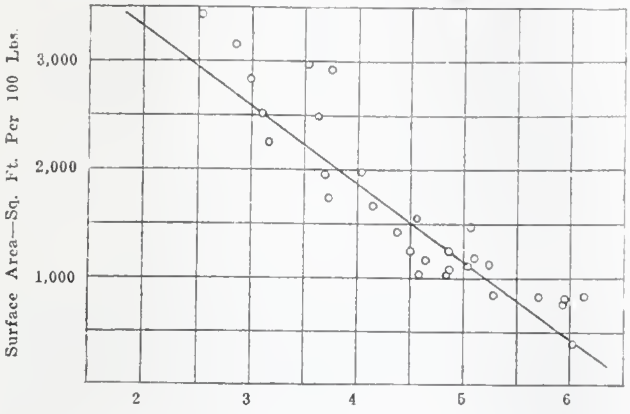

Fig. 1—Relation Between Fineness Modulus and Surface Area of Graded Aggregates. (From Hydro-Electric Power Commission's Tests.)

Prof. Abrams' method is based primarily upon a relationship which he has discovered between the compressive strength of a concrete and the ratio between the volume of water and volume of cement used in producing it. He claims that for given concrete materials, the strength depends on only one factor, the ratio of water to cement, called for convenience the water-cement ratio, that this relation holds so long as the concrete is workable, and that the character of the aggregate makes little difference so long as it is clean and not structurally deficient, and so long as proper account is taken of differences in their absorptive qualities. From this he concludes that the size and grading of the aggregate, and the quality of cement, are of no importance except in so far as these factors influence the quantity of mixing water required to produce a workable concrete.

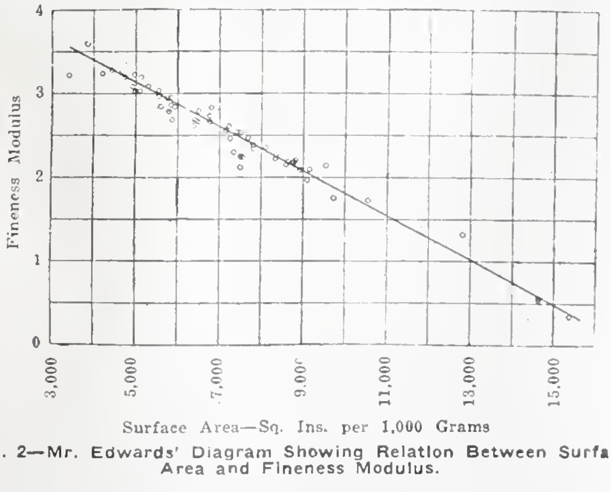

Fig. 2—Mr. Edwards' Diagram Showing Relation Between Surface Area and Fineness Modulus.

The fineness modulus of an aggregate is obtained from its sieve analysis. The percentages of material coarser than each of the sieves used, is summed and the result divided by 100. Prof. Abrams has standardized on a particular set of sieves, the basic sieve of which is the No. 100, having a sieve opening of 0.0058 in. In each succeeding sieve of the series, the opening is double the width of the preceding one.

Prof. Abrams claims that this fineness modulus enables one to interpret properly the sieve analyses of an aggregate, and that all aggregates of the same fineness modulus require the same quantity of water to produce a mix of the same plasticity and to give concrete of the same strength, so long as the aggregate is not too coarse for the quantity of cement used. This, he says, is because the fineness modulus simply reflects the changes in water-cement ratio necessary to produce a given plastic condition.

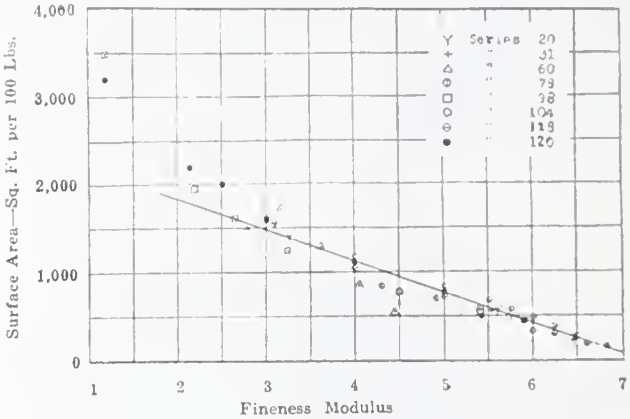

Fig. 3—Relation Between Fineness Modulus and Surface Area—Derived From Results of Prof. Abrams' Tests.

Mr. Edwards' method is based on the theory that for uniform plasticity and uniform strength, the cement varies as the surface area of the aggregate; and further that the quantity of water required to produce mortars of uniform consistency is a function of the water required to reduce the cement to a "normal" paste and of the surface area of the sand particles to be wetted.

In other words, Mr. Edwards claims a relation between strength and surface area, and between mobility and surface area and his tests support his theories so far as mortar mixtures are concerned. Later tests by the Hydro-Electric Power Commission of Ontario, under the direction of the writer, show that these conclusions are equally applicable to concrete mixtures.

Mr. Edwards obtains the surface area of an aggregate by counting and weighing some of each size of aggregate obtained in a sieve analysis, and from this data determining the average number of particles per unit weight for each size. Then, assuming these to be spherical, and knowing their specific gravity, he calculates the average volume per particle, the surface area per particle, and hence the total surface area per unit weight for each size of separation.

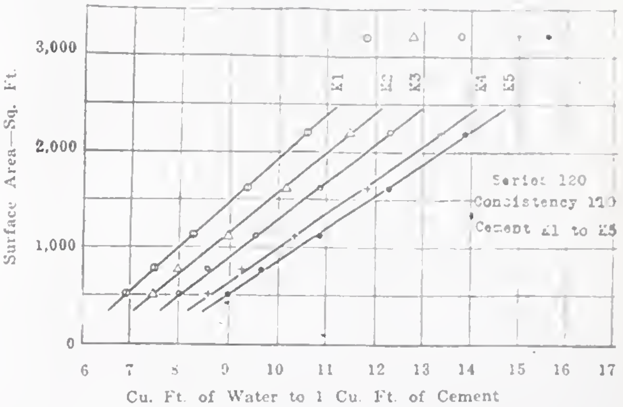

Fig. 4—Relation Between Mixing Water and Surface Area to Give Constant Plasticity. (Derived From Prof. Abrams' Tests.)

The surface area of any mixed material can be found by multiplying the surface area per unit weight of each size of separation by the weight of that size present in the material, and adding these. The value thus obtained is not the true surface, for the latter cannot be obtained, as the particles are not true spheres, are variable in shape and have not smooth surfaces. However, this value undoubtedly bears a constant relation to the true surface area, and for all practical purposes is equally as useful.

The Bureau of Standards, Washington, D. C., made a limited series of tests to check the findings of these investigators. As a result the Bureau claims that the water-cement ratio is only an incidental relation of no direct value to the engineer in proportioning concrete, that a wide difference in strength is found with constant water-cement ratio and that there is no relation between surface area and strength. These conclusions directly contradict the findings of the two last-mentioned investigators.

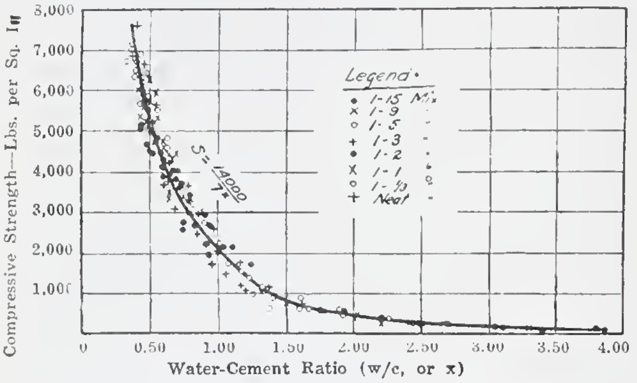

Fig. 5—Prof. Abrams' Diagram Showing Relation Between Water-Cement Ratio and Strength of Concrete.

At a later time, however, the Bureau makes this interesting statement. "Our tests indicate that for constant flowability the water required varies with the surface area of the aggregate."

Other investigators are working upon these different theories, although their results have not yet found their way into print. Prof. A. N. Talbot, of the University of Illinois, has said of his investigations, carried out upon concretes of one consistency and cement content:

"The tests indicate that for an aggregate having a given size of particles, the amount of mixing water required to produce a concrete of a given consistency, or mobility, is equal to a constant plus a term which is dependent upon the surface area. The tests show that the strengths of these concretes, made up to have the same mobility, are also dependent upon the surface area. Concretes having the same water-cement ratio give nearly the same strength through a part of the range of water-cement ratio values, but for each maximum size of particle, the results diverge from the main curve,—this occurring at places along the curve which vary with the maximum size of particle and which are quite far apart."

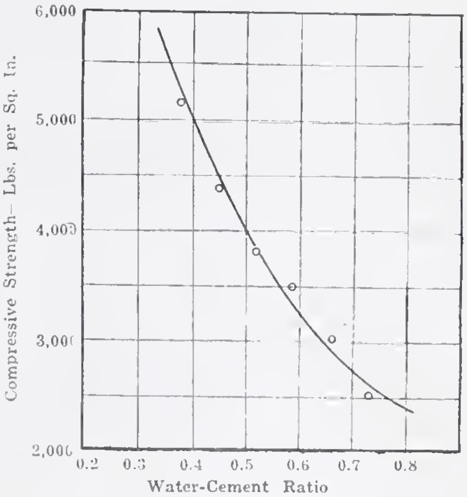

Fig. 6—Relation Between Water-Cement Ratio and Strength of Concrete. (Platted From Mr. Edwards' Tests.)

The Hydro-Electric Power Commission of Ontario has been conducting investigations along similar lines. Some of the conclusions so far reached are:

1. That the fineness modulus is but another and somewhat approximate method of defining the surface area.
2. That within the range of workable mixtures, both the "strength" and "water required to bring a mixture to a uniform degree of plasticity" vary with the surface area, the relation being actually that described by Messrs. Talbot and Edwards.
3. That there is a fixed relation between water-cement ratio and strength for mixtures of the same cement, same aggregate and same age.

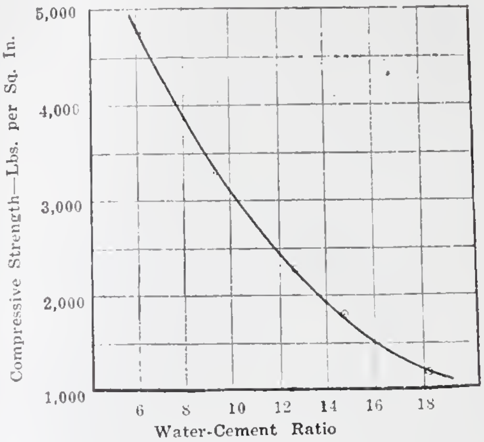

Fig. 7—Relation Between Water-Cement Ratio and Strength of Concrete. (Platted From Bureau of Standards' Tests.)

Fineness Modulus and Surface Area.—Figure 1 shows the relation found when the fineness moduli of mixed aggregates are platted against their surface areas as determined by the Edwards method.

This figure is similar to one given by the writer in The Canadian Engineer, June 26, 1919, issue, except that it covers materials from dust to 1½ in., while the former included only sands graded from dust to ¼ in. In the article just referred to, algebraical expressions for both the fineness modulus and surface area were derived, and it was shown that no mathematical relation exists between them. While an infinite number of values of fineness modulus may be found for any one value of surface area, and vice versa, yet it is a remarkable fact that for the materials ordinarily encountered, fineness modulus varies approximately with the surface area.

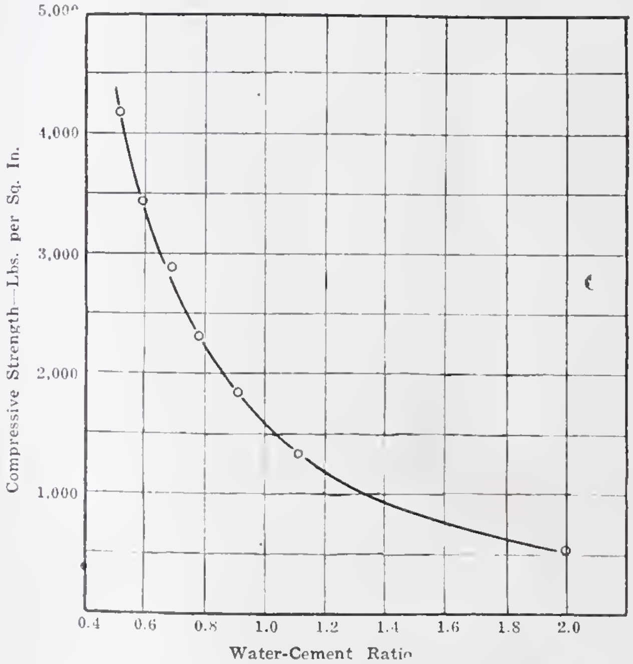

Fig. 8—Relation Between Water-Cement Ratio and Strength of Concrete. (Hydro-Electric Power Commission's Tests.)

Figures 2 and 3 show similar curves obtained from the data of Mr. Edwards and Prof. Abrams, respectively.

Figure 2 was reported by Mr. Edwards in The Canadian Engineer for Oct. 9, 1919, while Figure 3 was worked up from Prof. Abrams' published results, and includes materials graded from O-No. 28 sieve to O-1½-in. sieve, a wider range than is included in either Figures 1 or 2.

The relationship is probably the explanation of the reason that Prof. Abrams has found fineness modulus to be a measure of the effective size and grading of the aggregate.

Consistency and Surface Area.—Prof. Talbot's conclusion that the water in concretes of equal cement, necessary to produce a concrete of a given consistency, is equal to a constant plus a term which is dependent on the surface area, is the same conclusion arrived at by Mr. Edwards in his study of mortars. The writer's studies of both theoretical and experimental data corroborate this conclusion. The engineers of the Bureau of Standards confirm this partially when they state that their tests indicate that for constant flowability the water required varies with the surface area of the aggregate. Prof. Abrams uses his fineness modulus to proportion mixtures to a given consistency, and to do this used a formula in which the water required is the sum of a quantity dependent on the amount of cement used and a quantity varying with the fineness modulus. Assuming fineness modulus to be another way of stating surface area, or vice versa, it is evident that the work of each of these investigators point to the same end.

It is, however, unnecessary to make the foregoing assumption to show that Prof. Abrams' results bear proof of this relation between mixing water and surface area at a given consistency. Figure 4, which was worked up from the data in his paper* on "Effect of Fineness of Cement," shows five series of mixtures in which cements of different fineness were used, each proportioned 1:4 by volume with six different aggregates of a wide range in grading. The mixtures were all gauged to a uniform consistency, the water to do this being determined by means of Prof. Abrams' water formula. It is a striking confirmation of the law outlined in the last paragraph, that in the case of each of the different cements, when the amount of mixing water used is platted against the surface area of the aggregate in the mixtures, five of the six points lie on a straight line. The sixth point represents a mixture in which the material was a very fine sand, 10 per cent of which was dust or silt. Under these conditions it is hardly to be expected that this point would agree with the other and more usual materials, because our means of determining equal mobilities are not such as to function accurately under these conditions.

The results of Figure 4 cannot be explained by the fact that the surface area and fineness modulus have approximately a linear relation, for in the series represented (see Figure 3, series 120), this relation is a slight curve.

Water-Cement Ratio and Strength.—Figure 5, taken from the article by Prof. Abrams which was published in The Canadian Engineer for June 6, 1918, shows the general relation found by Prof. Abrams between compressive strength and water-cement ratio. This curve covers an extremely wide range of mixtures, materials and consistencies. Figure 6 is platted from the results of Mr. Edwards' mortar tests and show a similar relationship for the range covered by his tests. In these tests the proportions were constant, but the consistency varies. Figure 7 is platted from data published by the Bureau of Standards from tests in which the consistency was nearly uniform, but in which the proportions varied. Figure 8 is a similar series carried out by the writer in the laboratories of the Hydro-Electric Power Commission of Ontario. Similar curves have been obtained in the same laboratory where the proportions were constant and the consistency varied. In all of these curves the mixtures used were plastic. The relationships are practically identical in each of these figures, showing very good agreement on this point.

Prof. Abrams has shown that for given materials and age, approximately equal strength will be obtained even with widely different grading of aggregate and consistency, provided that the mixtures are plastic and that the grading is not too coarse for the quantity of cement used.

Mr. Edwards in his early tests on surface area proved the same things, for he varied both the cement and water according to the surface area and obtained a constant water-cement ratio, and his mortar mixtures were of nearly equal strengths.

It is hard to reconcile the Bureau of Standards' claim that "a wide difference in strength is found with constant water-cement ratio even with the same aggregate and cement," unless it is that these tests were designed to give unusual conditions.

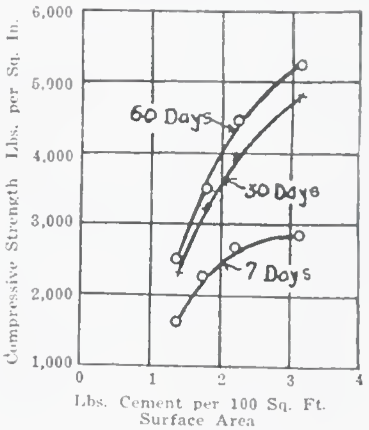

Fig. 12—Relation Between Cement Content and Compressive Strength. (Platted From Mr. Edwards' Tests.)

Prof. Abrams, in commenting on the Bureau's tests, has said of the aggregate used: "Over 40 per cent of the aggregates were too coarse for the quantity of cement used; 26 per cent of the mixes were too dry; 21 per cent were both too coarse and too dry; 72 per cent of the aggregates were of freakish grading." The writer agrees with Prof. Abrams' criticism, and considers this to be the explanation of the unusual results obtained.

It is interesting to note that Figure 7, drawn from data obtained by the Bureau of Standards before the controversy arose, while not bearing upon the disputed question of equal water-cement ratios having equal strengths, shows that a

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*Presented June, 1919, before the American Society for Testing Materials.

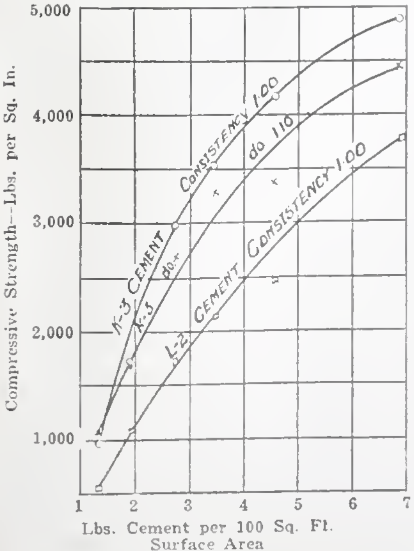

Fig. 9—Derived From Prof. Abrams' Tests.

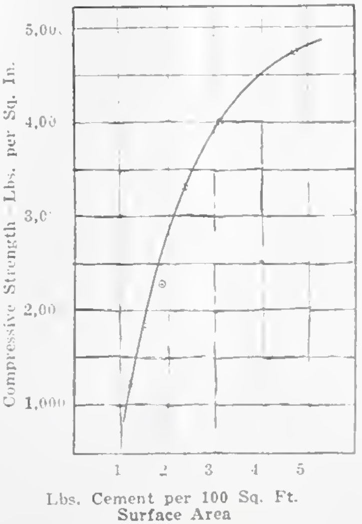

Fig. 10—Derived From Bureau of Standards' Tests.

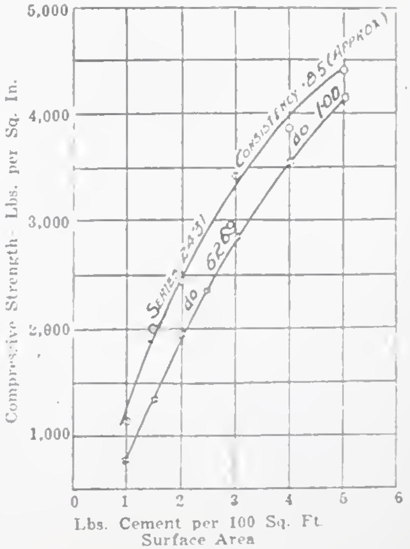

Fig. 11—Derived From Hydro-Electric Power Commission's Tests.

Relation Between Cement Content and Compressive Strength of Concrete.

consistent relationship is being obtained in this laboratory for commercial aggregates and plastic consistencies.

Surface Area and Strength.—If, for workable mixtures of similar materials, a given strength coincides with a fixed water-cement ratio, then it is evident that if the quantity of water required to bring a concrete mixture to a uniform degree of plasticity is a function of the surface area of the aggregate, the quantity of cement required to maintain this fixed water-cement ratio is likewise a function of surface area.

Conversely, if a fixed plasticity is maintained and the cement content of the mixtures are constant, then the compressive strength varies with the surface area of the aggregate. Both of these points have been brought out nicely in the tests by Mr. Edwards.

Compressive Strength and Cement Content.—In the writer's article, published in the June 26, 1919 issue of The Canadian Engineer, the form of the theoretical relation between compressive strength and the cement content of a mixture was derived. The cement content was given in terms of "pounds of cement per 100 sq. ft. of surface area," a unit which has been adopted by the Hydro-Electric Power Commission in all of its work. Figures 9 to 12 show curves of the same form obtained from the experimental data of the investigators referred to, with the exception of Prof. Talbot. In the case of the tests of Figures 9 and 12, the original results were obtained by other than the surface area method of proportioning. These curves are strikingly similar and are further evidence of the agreement between the data of the different investigators.

It is not within the scope of this article to discuss the relative merits of either the fineness modulus or the surface area methods of proportioning. Enough has been brought out, the writer believes, to show that they are simply different adaptions of essentially the same data.

Shortcomings of Fineness Modulus.—The fineness modulus of evaluating an aggregate has one serious shortcoming not present in the surface area method: It is dependent upon the number and sizes of the sieves used in its determination.

The surface area method is not so dependent; the same result can be obtained with any one of the commercial series of sieves in common use, because the surface area of an aggregate is a property of the material and not of both the material and the size and number of the sieves used in the sieve analysis.

A modification of Mr. Edwards' surface area method is being successfully applied by the Hydro-Electric Power Commission in the construction of several of its power developments. It is working satisfactorily and is giving better concrete with less cement than is being obtained on work where it is not in use. It is simple, and has been found easy to introduce into the field. It is not a panacea for all the ills of concrete, and its successful use requires careful inspection, intelligent supervision and a certain amount of laboratory assistance, but these are necessary with any method if good concrete is to be produced. It can be made to do all that is claimed for the "fineness modulus method," and it has certainly been found simpler to "put over" in actual field work.

Higher Salaries for State Highway Engineers.—The convention of the American Association of State Highway Officials, held in Louisville early in December, endorsed by resolution a list of recommended salaries for engineers in state highway service prepared by the Committee of the American Association of Engineers on Salaries of Engineers in Public Service. A. N. Johnson, consulting highway engineer of the Portland Cement Association, who is chairman of this committee, in addressing the convention stated that the recommended salaries were established by first selecting three places in the schedule; the highest, the middle position, and the lowest. The highest position was that of the chief engineer of the state highway department; the middle position was "considered to be one requiring an engineer having at least four or five years' experience since graduation from college; a man who it may be expected will be married. Such a position should, therefore, carry with it a salary to enable a young engineer with a small family to live in comfortable and appropriate surroundings." The lowest position was established as one filled by a recent college graduate. The salaries established by these three positions are $8,000 to $15,000 for the highest; $3,600 to $5,000 for the middle position; and $1,200 to $1,500 for the lowest.

Membership Drive of A. A. E.—The results of the national membership drive held by the American Association of Engineers during the first two weeks in December have not yet been completely tabulated. Owing to the coal strike during this period and severe weather throughout the entire country, almost without exception, results have been delayed, but more than 5,000 applications have already been received this month and they are still coming in. The highest percentage of increase of any one chapter that has been reported so far is in excess of 300 per cent, reported by the Buffalo Chapter. This percentage covers the growth of the chapter during Dec. 1st to 13th inclusive.

Personals

Charles F. Keating has been appointed director of public works of Watervliet, N. Y.

C. E. Rice has resigned as engineer of the City Planning Commission of Akron, O.

Gannett, Seelye & Fleming, engineers, who have their main office in Harrisburg, and a branch office in Erie, Pa., have opened a branch office in the Randolph Bldg., Memphis, Tenn., under the direction of T. E. Seelye.

E. W. McCoy and J. E. Hammond, graduates of Ohio State University class of 1912, in civil engineering, have opened an office in the Brunson Bldg., Columbus, O., for general engineering work. They recently returned from overseas service.

Lt. Col. H. S. Crocker, formerly constructing quartermaster of the Army Supply Base at Brooklyn, N. Y., and Capt. F. S. Crowell, a member of his staff in charge of pier construction, have opened offices as consulting engineers at 101 Park Ave., New York.

H. J. Doolittle, for the past 6 years district engineer for the Washington State Highway Department, has been appointed highway construction engineer for Spokane County, Washington, at a salary of $5,400 per year. The county will spend $3,250,000 in constructing 300 miles of roads. Mr. Doolittle's salary in his new position is $5,400 per year.

Obituaries

Ephraim C. Walker, a building contractor of Johnstown, Pa., died Dec. 16, aged 73.

Andrew Muir, one of the pioneer railroad tunnel builders of California, died Dec. 14 at his home in St. Paul, Minn., aged 82. He built the Bozeman and Muir tunnels on the Northern Pacific line in Montana. In 1900 he constructed the Franklin tunnel for the Santa Fe. He was one of the builders of the old Santa Cruz narrow-gage line, known as the Dumbarton system.

Robert Van Buren, who, until he retired on Sept. 1, 1914, was for 49 years chief engineer of the Department of Water Supply in Brooklyn, died of infirmities of age last week in Norwalk, Conn., where he has been living for several years. He was graduated from Rensselaer Polytechnic Institute as a civil engineer in 1864. In 1865 he received an appointment as a rodman in the service of the old Water Board in Brooklyn. Two years later he was appointed chief engineer of the Brooklyn Department of City Works and for several years in addition was in charge of the Sewer Department and Water Works, Dock Department, Bridge Department and Department of Public Buildings and Streets. After serving the city for 17 years he resigned in May, 1894, but four years later was appointed by Mayor Van Wyck as chief engineer of Water Supply in Brooklyn.

Industrial Notes

Henry P. Thompson, Cincinnati, O., a district representative of the American Steam Conveyor Corp., Chicago, has added to his sales engineering staff Mr. Albert A. Casey, who will push the sale of the American steam jet conveyor in that territory.

The Studebaker Co. has sold its dump wagon business to the Western Wheeled Scraper Co., of Aurora, Ill., who will continue the manufacture of "Studebaker model" dump wagons and will furnish extra parts and repair parts for them. Studebakers have decided to become farm wagon specialists and as such their efforts will be to make the reputation of the Studebaker wagon even better than it has been enjoying for the past 67 years, if that is possible.

Smith & Sons Mfg. Co., Kansas City, Mo., manufacturers of the Royal line of road grading and contracting machinery, has appointed the following salesmen in Iowa: R. F. Milham, will travel the Southeastern block in Iowa, with headquarters at Oskaloosa. B. R. Graham, the Southwestern block, with headquarters at Des Moines. C. B. Durst, the Northeastern block, with headquarters at Waterloo. C. F. Simpson, the Northwestern block, with headquarters at Ft. Dodge.

The Sinclair Refining Co. announces the formation of an asphalt sales department to handle the output of the Meraux, Louisiana Refinery, formerly owned and operated by the Freeport & Mexican Fuel Oil Corporation. The plant will be devoted exclusively to the production of refined asphalt from specially selected heavy Maltha from the Panuco Field in Mexico. It is the intention of the company to produce a complete line of high grade asphalts for all purposes. A large number of tank cars specially equipped for handling asphalt is already in service, and the equipment is being steadily increased. The headquarters of the new department will be located in the Conway Bldg., Chicago, Ill., and Mr. F. F. Fitzpatrick has been appointed manager and J. M. Woodruff, assistant manager.

The Milwaukee Corrugating Co. of Milwaukee, Wis., is again distributing bonuses among its employes. This is a practice the company started a few years ago, at the holiday season, and which it has kept up without a break, in spite of the war and building trade restrictions. The bonus amounts to one full month's salary, if the employe has been with the company one year; three-quarters, one-half and one-quarter of a month's salary are given to those who have been in the employ of the company nine, six and three months respectively. The management notified its employes that this bonus was given to them in appreciation of their loyalty and faithful services and in view of the present unusual conditions. They also suggested that this money be invested in Liberty Bonds or other safe securities, in order to provide for a "rainy day," rather than immediately spending it for amusement or for luxuries and non-essentials.

Foreign Engineering Review Quarterly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $3.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
- (a) Roads
- (b) Streets
- (c) Street Cleaning
- (d) Municipal Miscellanies
- (e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
- (a) Waterworks
- (b) Sewers and Sanitation
- (c) Irrigation and Drainage
- (d) Power and Pumping
- (e) Management and Office System

Railways and Excavation—3rd Wednesday
- (a) Excavation and Dredging
- (b) Rivers and Canals
- (c) Quarries and Pits
- (d) Railways, Steam and Electric
- (e) Management and Office System

Buildings and Structures—4th Wednesday
- (a) Buildings
- (b) Bridges
- (c) Harbor Structures
- (d) Miscellaneous Structures
- (e) Properties of Materials
- (f) Management and Office System

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Our Foreign Engineering Review Issue

In spite of the fact that British and European engineers have not yet recovered from the effects of the war, they are writing many articles that should interest and instruct American engineers. And, as construction activities increase in foreign countries, there will assuredly come from them a better quality and greater quantity of engineering literature.

It will continue to be our policy to abstract the best foreign articles and society papers relating to the civil engineering field, and to present these abstracts in a special issue, like the present one, every three months. Our four quarterly issues for 1920 would fill a standard book of 640 pages. This should serve to keep most of our readers sufficiently well supplied with foreign engineering literature.

To all our old subscribers, and to the rapidly growing number who, we hope, will eventually be classed with them, we extend greetings and wishes for a happy and prosperous new year.

A Series of Articles on Logic

During 1920 there will appear in Engineering and Contracting a series of 20 articles on practical logic by Halbert P. Gillette.

Although logic has been called "the science of sciences," and although every science progresses continuously, logic has been almost a stationary science for half a century. For 22 centuries, there has been very little improvement in the methods of presenting deductive logic. Is logic, therefore, an exception to the rule that sciences progress? It seems more probable that a science of logic has never existed, and that what has been called a science of logic has really been mainly a system of phraseology upon which has been grafted a few rules for inductive reasoning, the latter being Mill's five "cannons" of induction.

In the eighth chapter of his second volume on Psychology, Herbert Spencer asserts that "logic formulates the most general laws of correlation among existences considered as objective," and that "reasoning is a division of subjective science" or psychology. He goes on to say that "reasoning is a classification of relations," or the "grouping together those which are like—the separation of the like from the unlike." Spencer's conception of logic, although published nearly 50 years ago, has never been applied by any author, yet it has a great deal of merit. However, we are inclined to think that he went too far in excluding the psychology of reasoning from logic.

Logic, it seems to us, should be regarded as a composite science, and it should discuss not only the subject matter of reasoning, which is energy and its categories, but the psychological processes of reasoning. Furthermore, it should describe systems of expediting thinking and of reducing the probability of erroneous reasoning. Finally, it should point out methods of mental training to increase the native ability of each reasoner, not only in respect of deduction and induction, but of creative thought.

This, we are aware, is a big program. We are also aware that it includes matter that Mill and Spencer assert should not be included in logic. But Mill and Spencer do not agree as to what logic should teach; and, as a matter of fact, it always has taught a rather heterogeneous lot of things. If logic is to be a true science of sciences, it must be heterogeneous. If it is to be practical it must not be confined to theories, but must show how they are applied and must train the mind in applying them.

Nearly every educated man talks a good deal about logical thinking, but relatively few think much about logic. Since teachers of logic have failed to make it a vital and growing science, may there not be a possibility that engineers can do what professional logicians have failed to do?

Let Editors Be Licensed

Public opinion in America is made, for the most part, by the editors of daily papers and magazines. In view of the great importance of editors, may the day not come when only licensed editors will be permitted to express an opinion? If so, licenses will be granted only to such editorial writers as are able to pass civil service examinations.

In anticipation of the coming of the era of licensed editors we now suggest that one of the subjects upon which there is greatest need of an examination is economics. Several hundred daily papers come to our office, and in going through them we have been impressed by the unanimity with which their editors are calling upon the public to "spend less and produce more." Yet what would such practice lead to if generally followed? Obviously it would result in industrial stagnation; for what is the object of producing more if it be not to sell the produce, and how can the increased produce be sold if there is a universal resolve to buy as little as possible?

Probably the reply would be that the money saved should be invested. If so, then some one must still spend it if there is to be any use derived from it. What the editors should tell the public is to spend less on certain things and more on other things—less on jewelry, for example, and more on education; less on clothes and more on houses; less on soft drinks and more on outdoor playgrounds.

Physicians are licensed on the theory that the public needs protection from incompetent treatment of the human body. Let editors also be licensed on the analogous theory that the public needs protection from incompetent treatment of the human mind.

The Relation of Prices to Money Supply in Europe and America

In another editorial article we have suggested the licensing of editors in order to protect the public from poor advice. The average editor at the present moment is so ignorant of the main cause of high prices that he seldom mentions it, in spite of the fact that he writes about three editorials a week on the subject.

Political economists have long been agreed that, if other things remain unchanged, an increase in the quantity of money produces an equal increase in prices. The following striking data are from the Manchester (England) "Guardian" for November.

	Currency (Pre-war 100).	Food prices (Pre-war 100).
United States (May)	173	181
Switzerland (June)	230	250
Denmark (July)	240	212
United Kingdom (August)	244	217
Netherlands (September)	270	203
Sweden (April)	275	336
Norway (May)	305	271
France (June)	365	*263
	...	†293
Italy (April)	440	281

*Paris. †Other towns.

The "Guardian" says:

> One of the most interesting features of the comparison is the contrasting of the expansion in currency with the rise in prices. The figures of 100 is taken as the standard for the pre-war years. For the United Kingdom the figures show that the currency in August, 1919, stood at 244, as compared with 169 in 1913, and retail food prices at 217, as compared with 100, the pre-war figure. In the United States in May, 1919, the currency was represented by 173 and retail food prices by 181, as compared with the pre-war standard of 100. In France the currency figure had reached in June last 365, and retail food prices 263 in Paris and 293 in other towns.

If we average the nine countries in the table above given, we find that currency averages 280 and food prices 250, which means that there is 2.8 times as much currency as there was before the war and that food prices are 2.5 times as high as they were before the war. This is a very close approximation to the law that prices increase in proportion to the increase in money.

Ignorant of such facts, or ignoring them if not ignorant, the average daily paper editor engages in almost daily tirades against profiteers, spendthrifts, work slackers, etc., instead of directing attention to the predominating cause of high prices.

To those of our readers who are interested in public welfare, we suggest clipping out this editorial and sending it to the editor of some daily paper.

"Why Do Most Practicing Engineers Study So Little?"

An editorial bearing the above title was printed in our Foreign Engineering Review Issue of Oct. 29. It caused some little discussion and has resulted in our receiving numerous letters commenting on it. Extracts from some of the letters from well-known educators follow:

Henry E. Riggs, Professor of Civil Engineering, University of Michigan.—I was much interested in your editorial "Why Do Most Practicing Engineers Study So Little?"

I think you have given a pretty fair answer. I think a little more stress might be laid upon the fact that the really successful engineers who have won a place for themselves are students and that you will find in the private library of most of these men a pretty good working library along their special line of engineering.

Your statement as to the number of colleges which do not subscribe for Engineering and Contracting is surprising as I can see no excuse for any college not having in its file of periodicals at least every American publication along engineering lines. The reason for this doubtless goes to the fact that there is a library committee which may be composed of men not in engineering at all whose chief interest is in mathematics, physics or one of the humanities.

Another reason is frequently found in the fact that teachers of engineering have never been in practice and are not at all in touch with the men who are active or prominent in the profession. Under such conditions, it is unlikely that any great interest will be developed.

There is one other factor that must be taken into account in discussing our engineering colleges and that is the fact that practically all of the curriculum is prescribed and most of it is made up of such subjects as mathematics, physics, mechanics, descriptive geometry and drawing, and the fundamental professional courses, most of which are problem courses not involving outside reading. In this respect the engineering course falls far short of literary courses, many of which are largely made up of lectures and very large assignments of library reading. Add to this fact the excessive enrollment in our engineering schools in proportion to the number of men on the teaching staff and I think you will find that you have explained in a large measure the failure of engineering colleges to develop the reading habit.

It is quite certain that our average American student is not inclined to do much library research nor is he apt to take assignments seriously unless those assignments are followed up by much laborious work on the part of the teacher. The foreign students, the Chinaman for instance, are entirely different and take these assignments seriously.

Were it possible to adopt your suggestion of problem courses which would involve a thorough library search, much might be done, but in the college with an enrollment of 1,500 to 2,000 students, with several sections of each subject, the practical working out would be difficult if not impossible, and such courses as a result are confined to the senior or graduate years.

I do not believe that we will ever live to see the day when any considerable number of our students are so developed as to take into their professional life a well developed habit of reading. The comparatively small number who are students will continue as now to be the leaders in the profession. The others must continue to be hewers of wood and drawers of water.

Quincy C. Ayres, Assistant Professor of Civil Engineering, University of Mississippi.—Your resumé of the shortcomings of the average engineer is timely; coming, as it does, on the eve of his awakening to a new conception of the responsibility and dignity of his status as an integral part of a learned profession. Recognition of service in civic prestige and adequate financial return is a powerful stimulant to individual ambition, and evidence is abundant that this recognition is coming; not only in congested manufacturing districts, but in the byways of agricultural sections as well. When the average man realizes that his knowledge, general and specific, can be cashed in at a definite, intrinsic value, varying directly with its scope, then, and not until then, in my opinion, will engineers as a whole mount a more exalted intellectual plane.

No one person, who is, perforce, engaged in making a living, can hope to devote that close attention to the entire mass of engineering literature that its proper assimilation requires; he can, and does, I believe, give, at least, a hasty perusal to those articles touching upon his particular line of endeavor or to those that are intimately related to his personal experience. I submit that this is all that can reasonably be expected of a busy man, who, oftentimes, is moving about too frequently to carry with him an extensive library. Furthermore, should he have occasion to compile a bibliography upon any particular subject, there are several avenues for ready reference at his disposal. Let him, first, consult his own memory, aided by a search of files in the nearest library; let him make use of the facilities offered by the libraries of many national engineering societies; or let him invoke the aid of "Engineering Index" or some similar service. I maintain that data thus gathered will consume every second of time he may have for their study!

Your diagnosis of the ailment in the existing method of teaching is pertinent; but it is a far less difficult matter to point out defects than to prescribe effective remedial measures. It is, of course, generally conceded that the prime function of a four-year course of instruction is to thoroughly ground the student in the broad principles that are the foundation of all engineering, and to supplement them by as many applications as time will allow. Further than this, we can only hope to teach him how to approach his problems and where to find the information needful for their solution.

Now, just how shall we establish this "habit of searching for facts?" One method that has been tried at the University of Mississippi for several years with good results is embodied in our "Ole Miss Engineering Association." Membership is made compulsory for every engineering student, from freshman to senior, each of whom is allowed a certain amount of credit toward his degree for work in this society. Three students each week are appointed to deliver a paper on some live engineering topic, the preparation of which always requires an independent search of current literature. Discussions of these papers are animated, thoroughly interesting and usually result in a very perceptible benefit to all concerned. While the method outlined is, perhaps, especially adapted to small institutions, where it is possible to give each student individual attention, I believe it is, at least, worthy of consideration by our larger colleges, and I submit it, therefore, for that purpose.

The revelation that only 34 per cent of American collegiate libraries subscribe to so well known a periodical as "Engineering and Contracting" is, at once, shocking and indefensible. To your query: "Is the failure of two-thirds of these colleges to subscribe for this journal ascribable to the ephemeral character or uselessness of its articles?" the answer, obviously, is "no." It is ascribable to a deplorable attitude of mind best depicted, in my opinion, by a phrase of recent coinage, namely, "innocuous desuetude." Our faces are set in the right direction, however, and I, for one, believe there is cause for optimism.

J. L. Van Ornum, Professor of Civil Engineering, Washington University.—When I read your editorial I was very much surprised to learn that only about one-third of our colleges, which have courses in civil engineering, subscribe to "Engineering and Contracting." We are among that fortunate minority, as we have been keeping it on our library table for the use of the students continuously since 1906.

We find that "Engineering and Contracting" is a very valuable periodical in this department. We and the students both use and profit from it. I quite agree with the general tenor of the editorial. For many years we have been training and encouraging the students in reading, digesting and reporting on articles in the current engineering periodicals, as well as utilizing the material in other ways in their college work.

We want you to know that we appreciate your interest in the progress of sound educational training as well as in professional practice.

Prof. Frederic Bass, University of Minnesota.—The concluding sentence of the editorial is, in my opinion, correct. It is to be regretted that the engineering colleges are not more fully realizing their great object. I am sure that they do succeed to some extent, but whatever their success has been in the past, it is by no means certain that it will be as great in the future unless continuous constructive criticism, such as you here present, is directed toward them.

Arthur G. Gehrig, Associate Professor in Civil Engineering, University of Nebraska. The lack of scientific reading on the part of engineers after graduation is in very large measure due, I believe, to a similar lack of general reading as a student. It is true that he often enters the engineering college library, but generally for the purpose of studying his own text book which he carries in with him. In high school fashion he looks upon the place as a study room rather than a library. The instructor should do all in his power to emphasize to the engineering student the potential value of the technical library. The librarian herself can do a great deal to help form the general reading habit if she will in novel ways call the students' attention to small groups of books on various subjects at different times.

My students have been urged to subscribe to at least one leading technical magazine in their particular line of work. One magazine in a student's room is worth more than fifty in the library. During the day when he is in the engineering library he is apt to be too busy with regular school work to do any general reading in the many technical magazines. A magazine in the room will be picked up and read when the press of other matters has disappeared, and it will be read with greater benefit. If the student is not a subscriber during his college days he is apt to overlook subscribing after graduation.

By way of summarizing:

1. Let every instructor urge every student to read some book other than his text book.
2. Let the librarian display certain leading books for the convenience of the student.
3. Let every student subscribe at once for the best technical journal in his line of work.

F. H. Newell, Professor of Civil Engineering, University of Illinois.—You have covered the subject in a very interesting way. I hope that the editorial has attracted discussion.

Regarding the essential part of the editorial itself, I have come to the conclusion that the rank and file of the engineers are not students because their education has been of a kind which has resulted in giving them a rather narrow viewpoint. My interest in the American Association of Engineers has been aroused largely by the desire to do what I can to enlarge the view of the engineer after he leaves college.

Effect of Sea Water on Reinforced Concrete Structures

The Society of German Portland Cement Manufacturers, in collaboration with the Material Testing Bureau at Lichterfelde and the Hydraulic Works Inspection Department at Husum, on the island of Sylt, have been experimenting for about 20 years in order to discover the most suitable mixture for concrete for sea-water structures. In this connection Dr. Gary has recently published a detailed report in a communication of the Material Testing Bureau, the conclusions of which are given as follows in Mitteilungen des Reichsbundes Deutscher Technik.

In order to obtain suitably strong structures in sea water, it is necessary to use cement which is as rich as possible in silicates, but poor in kaolin and iron oxide. Such cements, when at the same time they are rich in lime, can be considerably increased in value by adding certain quantities of trass. The decisive factor, however, for the permanence of concrete structures in the sea is the use of mixtures which are as dense as possible and impervious to sea water, while at the same time sufficient external hardening should be given to the substances before they are placed in the sea by exposing them to heat and to moist air. Concrete, the mortar of which contains more than $66\frac{2}{3}$ per cent of sand, will generally not show the necessary density to enable it to stand attacks by sea water for any length of time.

Proposed Huningue-Strasburg Canal.—It is proposed to construct a canal running from Huningue to Strasburg, and to make a port on the river at the latter city. The canal will be 120 m. broad and 6 m. deep, and would be constructed so as to facilitate the erection of ten hydro-electric power stations with a total of about 700,000 hp., and costing one milliard francs.

Some Present Day Problems of Engineers

Editorial in Engineering, London, Nov. 7, 1919.

Life has been aptly described as the continuous adjustment of the organism to its environment, and the definition may undoubtedly be extended from the individual to the organization. Our national records are rife with instances of societies or corporations which have proved too inert to move with the times, and have ultimately utterly outlived their utility. It is a healthy sign, therefore, that several of our leading technical societies are earnestly engaged in studying proposals for enlarging their field of usefulness and increasing the attractions they already offer to prospective members. One of the most popular of the suggestions made to this end, is the establishment of local associations affiliated to the parent body. Provincial and Colonial members would thus, it is claimed, have greater opportunities for social intercourse, the promotion of which between its members is admittedly one of the proper functions of a technical society. In his interesting address delivered to the Institution of Civil Engineers on Nov. 4, Sir Joseph Purser Griffith made a strong plea in favor of this policy. As in most other mundane matters, however, the arguments are not wholly on one side. All our great societies have many members resident in regions where engineers are few and far between, and in which it would accordingly be impossible to establish a successful branch of the parent body. It is to the interest of such members, and they are many, that the surplus funds of the Institution should be devoted to the continuous and systematic improvement of the society's publications rather than to the formation of local associations.

In another part of his address the president drew attention to the fact, that though Ireland is a small country, Irishmen, or perhaps it would be fairer to say Anglo or Scoto-Irishmen, have played a very prominent part in several fields of engineering effort. He claims for Ireland the credit of producing the largest telescope, the largest ships, the largest sluices, and the largest linen works and the largest rope works yet constructed. In some respects the most noteworthy of the above achievements was the great telescope at Parsonstown with its 6-ft. mirror. This was not merely designed, but was also constructed by Earl Rosse in his private workshops with the aid of a capable smith and such other assistants as he could readily obtain. The successful completion of this delicate piece of work under such conditions is a striking instance of what can be accomplished by a man of genius, when backed by willing, if untrained, labor. The president might, indeed, have substantially increased his list of the indebtedness by engineers to representatives of what it has been common, in some quarters, to call the "garrison" of Ireland. Through Sir Benjamin Baker this small community has a claim to share in the credit for the construction of the Forth Bridge. The names of Lord Kelvin and Osborne Reynolds again are familiar to all for their great and original contributions to the art and science of engineering; whilst to Sir Charles Parsons the world owes the steam turbine, which has halved the fuel consumption of electric generating plants and reduced the capital cost to an even greater degree.

The physicist is fortunate in that he has to wrestle only with matter, whilst the engineer, in his struggle with nature, is handicapped by the necessity of working by and with men. The difficulty of securing the harmonious co-operation of labor has been steadily increasing year by year. Directly and indirectly the struggle has checked the creation of wealth, and diminished the average standard of well-being of the community as a whole, and its poorer members in particular. As others have done before him, Sir Joseph Griffith looks forward to co-partnership as a possible panacea for the evil. Undoubtedly, as some of the labor leaders frankly admit, part of the labor unrest is due to ignorance, and the history of the South Metropolitan Gas Co. during the past few years affords grounds for believing that the admission of workmen's representatives as active directors of an undertaking does tend to allay the suspicion that the laborer is being denied his fair share of the products of his industry. It is not a little noteworthy that the scheme so successfully worked out by Sir George Livesey had to be carried through in the teeth of the strenuous opposition of organized labor, and it will be remembered that the well-intentioned plan of co-partnership promoted by the late Lord Furness came to grief on the same rock. Moreover, in view of the frequency with which organized labor has of late years thrown over agreements negotiated by its duly elected representatives, it is at least an open question whether workman directors may not equally fail to retain the confidence of those they represent. Nevertheless, as ignorance is in the main at the bottom of most of the labor unrest of today, there is much to be said in favor of the proposal to introduce, where practicable, workman directors on to the boards of industrial undertakings. This, however, can be possible only when an enterprise has attained a certain stage of development.

Great creations of wealth are invariably due to the genius of some one individual. As the director of an ordinary limited liability company or as the manager of a co-operative society the late Mr. Carnegie would never have built up the steel industry of America. Indeed, as matters were, it is reported that he quarrelled with each of his partners in succession, and his ultimate success was attributable to the fact that he was able during the whole period of development to maintain a controlling interest in the undertaking, and thus could pursue his personal policy regardless of the doubts and fears of his less far-seeing associates. The result was to hasten the development of the American steel industry by perhaps 50 years. As one consequence life today is easier for every American citizen, whatever his position in society, than it would have been had Mr. Carnegie's pluck and enterprise been curbed by the necessity of satisfying some board of mediocrities as to the wisdom of every move he made. The universal introduction of working men directors would therefore, we fear, seriously check the creation of wealth in this country. In fact, it is very noteworthy how extraordinarily little has been effected in this way by the co-operative societies during the long term of their existence. They have invariably played for safety and left all pioneering work to others. It is in this pioneering work that great wealth is created or dissipated, and the nation that contents itself with the role of a mere copyist is little likely to enjoy any very high level of prosperity. Still, although for the reasons stated we do think that the appointment of workmen as directors might prove disastrous in many undertakings, there are undoubtedly others in which their presence on the board might prove of great advantage, and in such cases we agree with the president that great good might be expected from the adoption of a policy permitting this.

Whewell and Inductive Sciences

Editorial in The Engineer, London, Nov. 7, 1919.

It is impossible to read the histories of physical science which have appeared within the last few years without calling to mind Whewell's "History of the Inductive Sciences." It appeared a good many years ago—the first edition in 1837, and the third and best-known edition just 20 years later—but, despite the advances of experimental science, it has lost nothing of the high qualities that made it eminent in its day.

Whewell himself was not a practical scientist, but he had acquired by close study a remarkable acquaintance with all the sciences, and the course of a life spent almost wholly in the University of Cambridge—he graduated in 1814 and was appointed Master of Trinity in '41—had acquired that critical acumen which is the strength of his two principal works, the "History" and the "Philosophy of the Inductive Sciences." He was the son of a house carpenter in Lancaster, and made his way by his own industry and talent. His "History" ranges over the whole field of experimental science, and touches the learning of the whole world from the moment that records began.

We may recall Sydney Smith's epigram that "science was his forte and omniscience his foible." The history is written as a whole in lucid and energetic English, rarely marred by loose sentences or weakened by lack of directness. Here and there it is illuminated by happy turns of thought and by effective analogies. But, above all, it is because Whewell was critical and analytical that his work stands out. He does not merely record facts and support them with quotations, as Sedgewick and Tyler, two American authors, do in their short "History of Science," which was published by Macmillan a year or two ago, and he is not content with such brief study as Schuster and Shipley give in "Britain's Heritage."

His object is higher and greater; he did not write a volume of references to make easy the road for college students, nor to display the glory of our national science. He recognized no international boundaries to knowledge; his only concern was with the developing of accurate thought in the investigation of physical phenomena. He finds in China, India, Egypt, Greece, and Rome the earliest flickerings of science, and step by step he traces the growth of the increasing light in all parts of the world, here contrasting, there collating, sometimes approving, sometimes criticizing, always analyzing, and always moving—sometimes through paths that seem obscure—to a well-defined end.

He is essentially speculative, but he contemns philosophical abstractions. "Man," he writes in one place, "is not a practical creature merely; he has within him a speculative tendency, a pleasure in the contemplation of ideal relations, a love of knowledge as knowledge." Herein Whewell himself is the mirror in which he sees mankind. But he continues. "The mind cannot but claim a right to speculate concerning all its own acts and creations; yet, when it exercises this right upon common practical notions, we find that it runs into barren abstractions and ever-recurring cycles of subtlety. Such notions are like waters naturally stagnant; however much we urge and agitate them, they only revolve in stationary whirlpools." A fine image of unprofitable argument.

Scientific and Industrial Research

Editorial in Engineering, London, Sept. 26, 1919.

The value of science became so obvious under war conditions, that the establishment of the Committee for Scientific and Industrial Research and its endowment with £1,000,000 met with little or no opposition. It was recognized practically universally that the masters of words, such as it has been the main aim of our traditional system of secondary education to produce, must give way to the creators of ideas, and the official whose principal qualification lay in his ability to write a readable report on any given subject, had to surrender the direction of whole fields of endeavor to others whose literary style might possibly be at fault, but who were endowed with insight and imagination.

Ruskin, master of English prose as he was, would have proved a poor substitute for men like Sir Herbert Jackson, who gave such effective help towards the solution of the problem of supplying the insistent military demand for varieties of glass previously obtained from Germany, or for those who gave us the Stokes gun or the tank, which in both cases were only forced on the departments concerned by extraordinary persistency and pertinacity.

The war is over, and the Ruskin school which holds with Plato and Socrates that truth can be reached by a priori reasoning unchecked by observation or experiment, is still numerically very strong and quite naturally includes a very large proportion of our journalists and public men. There is therefore some danger that a strongly backed movement may arise urging the abolition or more probably starvation, of the Department of Scientific and Industrial Research, as one step towards that drastic reduction in our national expenditure which all parties are agreed is essential if bankruptcy is to be avoided.

Our characteristic tendency to demand results immediately profitable will undoubtedly be worked for all it is worth by the leaders of any movement of this kind, and it is fortunate therefore that the department, though established barely four years, can already point to a number of cases in which investigations aided by it have been of direct benefit to certain of our industries. Much of its energies have, of course, been directed to warlike ends.

The committee, whilst establishing and financing a considerable number of research sub-committees directly responsible to it, has throughout held in view of the desirability of assisting researches initiated by the industries themselves. This is most important as a centralization of research would almost certainly result in stagnation, independent centers of thought being essential to progress. The plan followed has been to contribute liberally towards the costs of research committees organized by these industries directly concerned. Of course, no one expects that organized research of this kind is likely to lead to revolutionary changes in our manufacturing methods. The creation of wealth on a large scale is commonly due to individual genius, a type of humanity which works badly under the direction of a committee, which has commonly to content itself with research of a somewhat humdrum character. The accumulated effect of a whole series of small improvements may, however, lead to very striking results. In the organic world Darwin attributed the whole development of the species to a long continued process of this kind, and we believe that biologists are returning to the view that much has been effected in this way, although there is a greater tendency than formerly to emphasize the part played by the "mutations" or large variations, which in the organic world correspond to the revolutionary work in industry of the man of genius.

Of these research associations, 17 have been licensed or approved up to date. In one or two cases, however, of which the shale oil industry is an example, the enormous increase in the cost of labor, has rendered manufacturers so doubtful as to the future of their trade, that the attempt to form a research association has been abandoned. The help afforded by the department is based in the main on the amount of the contributions directly subscribed by the industry concerned. In exceptional cases, however, for example that of those "key" industries in which the total annual turnover is too small to provide adequately for the researches contemplated, the contribution of the department is increased. Thus in the case of the British Scientific Instrument Research Association the department has arranged to contribute £61,000 or £70,000 if the members will themselves provide an immediate contribution of one-tenth these amounts. Similarly the Glass Research Association is to receive £20,000 per annum if its members provide £5,000 per annum themselves.

Results of industrial importance have already been attained in glass-making, china-making, mining and metallurgy. It is announced that matters have now progressed so much that the manufacture of hard porcelain on a commercial scale is to be undertaken forthwith. The history of the manufacture of china in Europe is of considerable interest. The Continent busied itself mainly in attempts to imitate the original porcelain of China, and when success was finally achieved the work was carried out for the most part in state-owned factories, in some of which the operatives were treated as close prisoners in the endeavor to prevent a knowledge of the factory methods spreading to other lands. Britain on the other hand, by private enterprise, invented and introduced a new form of china, having in some important regards considerable advantages over the Oriental type. The latter, however, is much superior to "bone" china for certain limited purposes, but its manufacture was neglected here until the war made it impossible to import from the Continent the supply required. This led to the researches by Dr. Mellor and Mr. Moore, which proved that we could perfectly well supply our own requirements in this regard.

In pre-war days refractories were also imported on a large scale from the Continent. In part this was due to circumstance that the majority of our makers were working on a comparatively small scale, so that there were difficulties in providing for a proper scientific investigation of the problems at issue. Here again the leeway has to a large extent been made good. The Seger cones, no longer obtainable from abroad, were soon replaced by equivalents prepared by Dr. Mellor, and we learn from the report that conspicuous success has attended the experiments made in the manufacture of gas retorts. A new method of casting 5-ft. retorts has proved its value, and thus a great improvement has been effected at the cost of a few hundred pounds. The Photographic Research Association have discovered a method of staining wood black or grey all the way through, and this process will doubtless find its application in more than one industry. The committee which have been investigating abrasives and polishing materials have succeeded in producing a new form of rouge which is quicker in action and altogether more satisfactory than any previously attainable.

In view of the present prices of tin, it is of interest to learn that by improved methods of treatment developed with the aid of the department, it is expected to increase the present yield of the Cornish ores by no less than 11 per cent.

Not much progress has been made in the purely engineering researches. The Committee on Lubricants have accumulated a good many data and discovered some striking peculiarities in the behavior of different lubricants.

The Industrial Fatigue Research Board has continued its work. In reports already published, cases have been brought forward in which a reduction of the hours of labor has actually been accompanied by an increase of output. On the other hand, recent reductions of hours worked in the engineering trades are said to have resulted in a decreased production almost exactly proportionate to the decrease in the hours worked. In part this may be due to the lapse of time being insufficient to establish the ultimate consequences of the change. The first effect of such a change is almost certain to be a reduction of output, but in some cases, at least, it has been found that, after a few months, matters have so adjusted themselves that the hourly output has increased sufficiently to compensate for the reduction in the time worked.

At any rate, it seems certain that maximum outputs can be secured only by a substantial increase in management expenses. Foremen have too commonly been overworked and underpaid, and far too little thought has been expended on making matters easier for the operatives. A workman can chip and file a casting even if he has to twist himself almost into a knot to get at it, but it will commonly prove cheaper in the end to avoid the necessity for such contortions. The importance of such consideration was very clearly shown in one shop during the war, which took up the manufacture of small shells. At the outset the intended output was hardly half of what had been anticipated, and a notable increase was effected by merely arranging that the blanks should be delivered to the workman at hand height instead of being piled on a heap on the floor near his machine, so that he had to stoop to pick them up. From first to last the recently issued report of the Committee of the Privy Council for Scientific and Industrial Research is suggestive and instructive.

Popularity and Progress

Editorial in The Engineer, London, Nov. 7, 1919.

We are reminded by what we have just written of a shrewd observation of Walter Bagehot's. "If any particular power is much prized in an age," he wrote, "those possessed of that power will be imitated; those deficient in that power will be despised. In consequence an unusual quantity of that power will be developed, and be conspicuous." Then, after alluding to the thought of Elizabeth's time, he concluded "In a word, the temper of the age encouraged originality, and in consequence original men started into prominence, went hither and thither where they liked, arrived at goals which the age never expected, and so made it ever memorable."

It is generally characteristic of a great truth that when divorced from the subject to which it belongs and applied to another it loses little of its virtue. Bagehot was writing of abstract qualities of mind, but the observation which forms the first part of the quotation above is equally applicable to concrete affairs. What has been aptly called fashion in engineering is an example in point. When canals were first made in England, England thought of nothing but canals, and anyone who halted in his admiration of them was "despised"; railways in their day had the same vogue, culminating in the railway mania of the late 40's; it is only a few months since aerial transportation monopolized public attention, and electrification is still with us.

The devotion of the public to a selected line of thought has, as Bagehot pointed out, a twofold effect. It leads, on the one hand, to a continual augmentation of the ranks of those who follow the popular course and depletes the ranks of those who do not. It counts, so to speak, two on a division. By winning to itself the intelligence of the day it robs other subjects of the thought they might have had, and so both strengthens itself and weakens them.

Examples may be found in the employment of the turbine for marine propulsion or in the electrification of tramways. The marine engine developed and was developing when the turbine came in, but the turbine stopped further progress because the genius and intelligence which might have carried the reciprocating engine further were diverted to the more popular turbine. In this case the decision was probably right. It is by no means so certain in the case of tramways. Electrification put an end to thought, experiment, and development in other directions, and by enlisting in its own service the great body of traction engineers and the financial resources of the public, robbed other means of propulsion of their power to progress. We may hope that the second part of the quotation may also be realized, and that some day a new Elizabethan morning will dawn and that once again it will be possible to say men "arrived at goals which the age never expected."

Specialization

Editorial in Engineering, London, Sept. 26, 1919.

Specialization is commonly considered as a distinctly modern element in manufacture, and its benefits in economic production are assumed to have been realized only in recent times. Actually it is the extensive application of a very ancient realization. There was once a time in the dawn of history when each individual produced all his needs, or failing some complementary qualities in his next of kin, went without. Later we find certain men set aside for special vocation as, for instance, priests and kings, soldiers and sailors, blacksmiths and millers—they could produce greater output with less effort if trained to specialist ends; the continuation of the process in due time made the Ford car a possibility. Each village community, after man lost to some extent his desire to club every stranger and learned that co-operation meant security, found employment for specialist artisans—saddlers, armorers, smiths, wheelwrights, carpenters. Now specialization did not invent the internal-combustion engine, that was more or less individualist research, but modern processes of manufacture are the outcome of the logical necessity which set apart the first carpenter or the first smith.

Curiously enough, the wheel of time has turned full circle, and the industrial operative of today has no need for definite and specific skill in a trade sense. Human muscle and the co-ordination of mind, eye, and training, has been superseded, and the propellant power applied to the tool is now mechanical power, so that former skill of craft has been penalized. We are reminded at due intervals, and the advice becomes more insistent, that the remedy for all engineering ills is specialization. What should, however, be insisted upon is that the cure for competitive manufacturing troubles is the said remedy.

A vast difference exists, and must continue to exist, between manufacture and the field of the engineer—between the craftsman and the operative. The opposed activities occupy different spheres, and should be so regarded. The engineer is a pioneer pitting trained skill against individual problems, the manufacturer is not concerned with original solutions but with settled processes and quantity production. It depends altogether upon the work in hand whether specialization is expedient: no panacea, whether medicinal or commercial, is of universal application.

Evolution in a mechanical sense covers a broad field. First comes original discovery, the work of the scientist, then reduction to the realm of practical things, the latter a work of great magnitude in many cases. Subsequently comes a period when improvement is rapid, and constant change the rule; finally, by process of time, method, material and design become crystallized, the market expands as the cost is reduced. Large demand justifies specialized manufacture only in the last phase. As a matter of fact, everything passes through the series of stages indicated, while there are always numerous things which for varying reasons never get to the finality of specialized manufacture, where sub-sectionalized labor and minute subdivision are warranted.

It is possible that when mechanical invention has exhausted itself—it must be remembered that it is the outstanding feature of the present age—when all the secrets of material and mechanism are discovered, or when the age pursues another activity—then manufacture will obey mathematical law with the symbols of capital, labor and supervision in a single equation. Until this period is reached, and the eventuality is not yet in sight, the place of the skilled engineer and mechanic who bridge the gap between discovery and popular need will be essential.

Specialization is not a very modern discovery even in its present aspect. Whitworth foreshadowed its trend quite ably, and it was always realized that quantity production led to revision of process and reduction in cost. The reason which explains why the advent of specialization in its modern guise was delayed was that sufficient quantity of one manufacture could not be secured to render interchangeable organizing methods possible, save only in the case of firearms. It was the sewing machine, the bicycle and later the automobile which permitted the adoption of the methods now held up as a paragon of logical perfection. The vast extension of finely-subdivided labor in the field of munitions is due first to a flexity of design and second to quantity; it is merely the original methods of rifle manufacture upon a larger scale.

Standardization and all it implies can only be successful where some finality in design is reached, it cannot be applied in an intermediate period where alteration is rapid and progress the rule. Only where vast quantities are involved with design fixed for a considerable period, can the skill of the craftsman be exchanged for the semi-skill of the operative. The method followed must be conditioned by circumstance and the ability to transfer skill or adapt machines is essential while evolution is the rule. The general application of munition methods and so-termed scientific methods to normal trade output is manifestly wrong as a settled and final conclusion.

A large proportion of the engineering work of the world consists of designs to special requirements to which specialist manufacture is inapplicable in the sense of the motor car or munition production. The Ford car is notorious not so much because it is a standardized production but because it is probably the most extensive article so produced. Bridges, ships, locomotives, boilers, marine engines, cannot be standardized in the same sense, nor indeed can anything which demands varying design to differing requirements. The 5,000-ton cargo tramp could be standardized perhaps—the quantities built would allow it; passenger vessels could not be so treated. There is room for an argument to justify less divergence in locomotive stock, each railway, for example, designs its own engines, which differ, but the locomotive is far from being a settled and final product even now. It is safe to infer that specialized production in the main must be kept within limits of size, thus introducing another factor beside quantity. Broadly, detail can be standardized more readily than design.

Again, it has been rightly pointed out that vast schemes of output of a single type can only be applied where demand can be foreseen and closely estimated, where for instance there is a huge domestic demand highly protected by tariff. Where foreign competition is forestalled, specialization is thereby rendered easier. If the manufacturer has a certain large preserve to supply, his additional export business is stabilized by normal home demand. Export then becomes merely an extension of the home field, not of necessity the greatest market. Where differing markets demand alteration and adjustment in design or type specialization is less applicable.

Every country is from time to time reminded by its foreign representatives that the tendency to force existing design upon an oversea market in place of studying requirements and altering standard articles to suit local conditions is a proceeding fraught with danger in international trade. Local circumstances or climatic conditions radically alter the character of desirable article. This is a valid argument against too intensive a cultivation of standardization and rigid specialization.

The danger attendant upon acute specialization is easily realized; it is in effect the snatching of present profit as against future progress. Certain things universal today are made obsolete by progress in a few years; there are few men who do not prefer more than one iron in the fire. Capacity for adjustment to environment is hampered by the outcome of rigid specialization. Transferable skill or plant is counseled by commonsense and is a measure of protection against obsolescence.

Specialization in an acute form is rather like being dependent upon a single customer who may decide to manufacture for himself, trade depends upon numerous customers for stability, and national manufacture in turn depends upon capacity to fill varying needs. Few workmen regard distinct and unequivocal specialization without misgiving; their expertness may in time be entirely scrapped by change or improvement. Adaptability of skill and organization of plant meant the possession of fluid as against fixed assets.

The result of the work of every inventor is to break up settled practice, unfortunately for acute specialization there is no means of calling a halt to invention, and for this reason alone the specialization of today may be abrogated by the progress of today leading to new specialization tomorrow. This is not to say that specialization of a rational type has no virtue, but before throwing overboard a genuine bone it is as well to be certain that the attractive shadow is just as valid. In its logical meaning specialization means confining effort within a very narrow tolerance, the more limited the field the greater the benefits, but the dangers are also multiplied.

Manufacture upon pious hope of a market is pure speculation, and while trade in its broadest aspect means the assumption of risk, there is a difference between the investment in Spanish gold and the attitude of a miser who starves rather than spend upon necessities. Somewhere between doing anything and doing a single detail lies the choice open, the two extremes are in effect not so very widely apart in their returns. The incongruity is less the more the facts are realized.

Transferable skill is of intrinsic value whether it is the possession of an individual or a limited company. Specialization has all its eggs in one basket, and the particular basket needs continuous and close scrutiny, and because greater risk is assumed greater returns are justified. That industry in some quarters could do with more specialized methods may be true, but that a broader basis of effort would be beneficial elsewhere is equally a valid contention. Danger lurks at both extremes of the manufacturing scale, and certainly where a country is mainly dependent upon export trade there is opportunity for the exercise of both activities. It is impossible to dogmatize; the question of specialization in a universal sense is obviously a danger, it depends upon the precise article, the volume of demand, its universality of utility apart from local conditions and numerous other factors.

Increased Technical Knowledge: a Legacy of the War

Editorial in The Engineer, London, Nov. 14, 1919.

The war has left behind it many things we would gladly be without; on the other hand, even apart from main issues, it has left us some things which we shall be wise to grasp and to value at their true worth. One of them, which we may regard as a valuable by-product of our fighting efforts, is an increase of our technical knowledge in certain directions. The stress of war forced us to study and investigate, and to put to practical trial on the largest scale and under the severest conditions a whole host of matters which in other circumstances might have been neglected for many years. Nowhere is our advance from this cause more marked than in our knowledge of the materials of engineering. It is a commonplace to say that the development of mechanical warfare led to the rapid evolution of a whole series of devices, such as the tank, the submarine, and the aeroplane and airship, which nothing short of war could have called into being so rapidly. But we must not forget that all this great mechanical development depended upon and went hand in hand with a corresponding development in the materials employed. This development, invaluable as it is, stands in danger of being lost or ignored now that peace conditions have returned.

In some cases the exigencies of mechanical warfare led to the evolution of actually new materials. Perhaps the most striking examples of this kind occurred in aircraft. We may mention the aluminium alloys used for pistons, as one example, and the protecting varnishes, applied to shield aeroplane wings from the ill-effects of sun and weather, as another. In a much larger number of cases, however, what happened was not so much the evolution of a new material as some important development in the use of one already known. To the credit of the technical branches of our War Ministries be it said that these new applications of materials were often the result of extensive and very thorough investigations carried out both in the laboratory and in the workshop and the field. As an instance of this kind we may quote the use of so-called "stainless" steel i. e., steel containing about 12 per cent of chromium, for aero-engine exhaust valves. Here was a material whose primary use appeared to lie in cutlery, which should save the burdensome domestic labor of knife polishing. But apparently the properties which protect stainless steel from corrosion at the ordinary temperature also protect it from scaling at high temperatures, and with this valuable property it combines a sufficiency of strength even when heated to a dull red. At the moment, it is true, we may not desire to build many petrol engines running with red-hot exhaust valves, but the evolution of machinery is rapid, and we need not take an excessively long view to contemplate the possibility of some invention—the gas turbine leaps to the mind—whose working parts would operate at these high temperatures. This of course, is but an isolated instance out of a very large number, and the knowledge upon which these new uses of materials are based, or which has been obtained as a result of their use in practice, is of the highest value. Fortunately some at least of the technical officers who had to deal with these matters during the war have devoted the requisite time and labor to the preparation of reports and papers in which a part at least of this great fund of knowledge is recorded. For their efforts we should be duly grateful, but the mere recording and publication of such knowledge is not enough; indeed, by itself it may even prove a serious disadvantage to our industries. For, if our industries fail to utilize this knowledge and to take the fullest advantage of the new possibilities, it is very certain that our industrial rivals elsewhere will not fail to do so. The use of the best possible materials for each special purpose is of greater importance today than it has ever been, not only because of the ever-rising standard of efficiency which is demanded of our products and machines, but also on account of the relatively higher cost of labor. Under conditions where the cost of an article necessarily depends upon the labor rather than upon the material the final value of the article will often turn mainly upon the quality of the material. Engineers, and users also, may therefore well be urged to pay the greatest possible attention to the choice of materials to be employed in the "peace products" to which their attention is now being devoted; nor need it be supposed that such attention will always lead to the adoption of a more expensive material. While war has taught us to value the special properties of expensive alloy steels, it has also taught us the possibility of utilizing cheap raw materials which we were formerly disposed to condemn.

Engineers will no doubt recognize the necessity of such a policy as we have indicated, and yet they may not be in a position entirely to save the situation without outside support. There are many valuable and important materials whose use in ordinary commercial practice at the present time is likely to be extremely limited. Where a material has been mainly employed for armament purposes the demand in the immediate future may be too small to justify the upkeep of even a small plant for its regular and satisfactory production. If such plants are permitted to shut down, then not only shall we be deprived of the possibility of using that material for military or naval purposes if or when the need arises, but it will cease to be available for industrial development purposes. Here lies a serious danger arising out of the present desire—natural enough in the circumstances—to restrict public expenditure, particularly on armament. During the war we felt the pinch from the lack in this country of "key" industries, and much is said of the imperative need for maintaining them here in the future. That is well as far as it goes, but in regard to materials it does not appear to go far enough. We must for future safety, from both the industrial and the military standpoint, maintain in our country not only the best and most advanced knowledge of materials, but also the skill and the appliances for their production and use. From this point of view the ruthless abandonment of so much experimental work in the navy and the air force must be regarded with the gravest misgivings. We do not want large armaments, but we do want, and must maintain our knowledge and our skill at the highest possible level, and it is for the government as well as for our industries to see to it that they are so maintained.

The Training of Engineers

Editorial in The Surveyor, London, Nov. 14, 1919.

The Yorkshire Association of Students of the Institution of Civil Engineers is to be congratulated on having obtained the services of Sir William Ellis as president for the ensuing year. The address which Sir William delivered at the last meeting of the association was very appropriately devoted to the question of engineering training, a subject upon which Sir William, with his long and distinguished career, is entitled to speak with authority. With regard to the vexed question as to whether practical training should be contemporaneous with a college course, or should precede or succeed it, Sir William was very decidedly of opinion that shop experience (he was speaking more particularly of the training of mechanical engineers) should come first. And for this he adduced a reason which has special force in these days—namely, that it is only by mixing with workmen while he is still young and in the earliest stage of his career that the engineer can hope to enter with sympathy into their aspirations and views of industry. That there should be such an understanding is obviously desirable on both sides. But in our view shop experience, even if gained early for the reason indicated, should be accompanied by at least elementary theoretical work, if it is to be used to the best advantage. We speak with some hesitation as regards mechanical engineers, but we are more confident in laying stress on the supreme value of practical office experience, accompanied by theoretical training, for those intending to embark on a career as municipal engineers.

Scientific Management in an Iron Foundry

Editorial in Engineering, London, Oct. 3, 1919.

A considerable amount of literature, dealing with the application of scientific management to various industries in the United States of America, has been published. So little is said about what is being, and has been, accomplished in this country, that it might well be considered that the movement is almost stagnant here. We are liable, as a nation, to underrate our own efforts and to overestimate the value of the organizations of competitive industrial states. As a matter of fact, signs are not lacking that, in the near future, the movement of scientific management will have achieved in our industries as great application as it has in the United States of America. The vast amount of American propaganda, conducted often by efficiency experts, is misleading, inasmuch as the movement in America is not so generally applied as these advocates would give our engineers to believe.

In all matters where new first principles are involved, where old-established methods—responsible on their part for considerable past success—are passed over or are even made the subject of minute examination and proved wanting, theoretical argument can only expect success after hard effort. The old adage that a small amount of practice is worth a great deal of theory in such cases is very true. Gradually, however, in this country practical experience is accumulating, and it behooves engineers carefully to watch such developments, giving credit where it is due. To this end a recent pamphlet issued by the Industrial Fatigue Research Board entitled "A Study of Improved Methods in an Iron Foundry," gives in simple language and concise form the manner and the results of the application of scientific management to an iron foundry. Moreover, as indicating the extreme value of this contribution to the literature on this subject, and as testimony to the efforts of British industries, it should be stated that the data given are not based on short periods of working, but are deduced from three full years of operation during the war period (August, 1915, to 1918).

The foundry in question—The Derby Foundry Company, Limited, or Derby—was concerned with the casting and molding of hand grenades, and the casting, molding and machining of fuse hole plugs. The authorities estimated the output to be 3,000 per week, but by August, 1916, 20,000 weekly were actually being delivered. Possibly the original estimate of 3,000 was too low, but, it is stated that a similar works with more plant were only turning out 5,000 weekly.

It has often been stated by those who were perhaps not too anxious to undertake the experiment of introducing scientific management on the Taylor system, that the objections which would be raised by the men and by their trades unions would be prohibitive and would absolutely preclude success in this country in most cases. In this connection, therefore, it is exceedingly interesting to note that the firm in question first of all consulted their men, and that throughout the whole time of inauguration and development of this system, little opposition was experienced, and that only in regard to minor points about some of which details are given. As we believe to be thoroughly essential to the obtaining of the full benefits of the system of scientific management, the preliminary investigations commenced with the training of the operators under a system of "motion study," where the various jobs were split up into their elemental units, each of which was studied with the aid of a stop watch, in order to eliminate superfluous movements and to arrange the appliances on the best scheme for maximum production. Combinations of such movements were regularly evolved. Each job had its typewritten card of instructions in regard to the movements necessary for each process, equated to the times requisite for their performance. These instructions were given with the minute detail consequent upon the original motion study which had been carried out and which indicated, for instance, whether the right or the left hand should be used.

It is estimated that of the great improvement in output achieved 90 per cent may be attributed to increased human efficiency. In the machine shop the even greater increase in total production that in other departments was largely due—though by no means entirely so—to improved efficiency of the machines. Naturally the duration of the training period of the worker varied with the personal equation. One of the most successful pupils, it is recorded, was a man who could neither read nor write, but, as his memory was developed to an extent considerably above the average, he could easily commit to memory the instructions received, and it was found that his period of training could thereby be considerably curtailed.

Each operator received separate instructions. Simultaneously with the commencing of training, the hours were reduced from 54 to 48 and were continued unchanged at 48 hours per week.

In conjunction with this application of scientific management an improved system of payment was evolved. During the training period workers received 25 per cent above the standard rate. So soon as the operator showed that the standard output could be maintained, he was put on to differential piecework, which is pure piecework, with the difference that the greater the number of pieces turned out or the greater the amount of work done per day or per unit of time, the higher the piecework price per unit of work. This system, of course, has been advocated and adopted to some extent for repetition work in America, and has the great advantage of offering a strong incentive towards maintaining the highest possible standard of efficiency. That this system is fair cannot be denied, since the greater the number of units of work performed, the less the rate to be allowed for certain overhead charges, etc., per unit, and therefore the higher the price per unit which can be paid as direct wages.

The disadvantages are such, however, that unless careful study, entailed by following fully the system of scientific management, be the preliminary step to the fixing of piecework prices, these inevitably become so haphazard as to cause in some cases too high earnings to be made, and in others, too low.

Differential piecework necessitates motion study. The system adopted in this case for increasing the piece rate per unit of work was such that workers of exceptional ability could turn out sufficient work to increase the price per piece by about 25 per cent above the standard piecework price. The possibilities of increase of earnings resulting from this application of scientific management may be shown by comparing the figures for a certain worker for six consecutive weeks prior to the introduction of the system, with those for another six consecutive weeks in 1918. The increase in earnings in this case was practically 200 per cent, neglecting, of course, in this comparison, all war bonuses and war advances. As usual, the assurance was given that the piecework prices would not be "cut." The overall figures, indicating the increase in production achieved by scientific management, in this case, have already been given. To deal with the specific case, a job which, before the war, gave an average output of 48 per day of 10 hours, was standardized under the system of motion study, at an output of 147 per day of 8¾ hours, meaning an increase of 284 per cent per day, or 350 per cent per hour, which was regularly surpassed by trained adult workers.

In the early stages of the application of this system, strong protests from the workers as to the impossibility of achieving the standard were not lacking. However, the men were willing to be trained in their work, and the results of the training rapidly dissipated these fears.

It should again be emphasized that, in this case, the nature of the work was extremely favorable to the experiment, the successful results of which are so well detailed in the pamphlet already mentioned. The work was repetition work of the truest type, the product did not change throughout the period under review. The demand was greater than could be met and was guaranteed by war conditions. The thought must arise that, had such methods been more generally employed in the industries of this country during the last few years, more particularly by those which were concerned with the production of the great mass of munitions of war, constituting essentially repetition work, an enormous saving in time, labor and the nation's capital, would have been effected.

Now that we are turning to the conversion of our swords into ploughshares in full face of the severe economic conditions resulting from the unparalleled expenditure of money and of energy throughout the war, any means towards increased efficiency which can be applied should be grasped. The difficulties should boldly be faced, and, although the first principles of scientific management may be considered to be most applicable to repetition work, it will generally be found on analysis that there is a very large amount of suitable work in many of our great peace industries. Experience of such methods as we have described would probably lead to extension of effort and broader application

Development of Power from Tides

Editorial in The Engineer, London, Nov. 21 1919

Brindley was once asked for what purpose he conceived rivers to have been created, and replied, with the splendid insolence of the genius and enthusiast, "To feed canals." The day may come when men will aver, in a similar vein, that the tides were established, nay, that the moon herself was fixed in the heavens solely to provide the United Kingdom with electricity at one-third of a penny per unit! The time is indeed not yet, but the milestones on the road are beginning to show through the haze of distance. When coal was cheap there was little probability that tidal power schemes would meet with success, not because as far as mere generation of power was concerned they could not compete with steam plant, but simply and solely because the cost of constructing the great civil engineering works needed for impounding the incoming waters and controlling their exit was so great that payment of the interest and redemption of the capital made such schemes financially unsound.

But things are changing. Coal has risen to three or four times its old price, and there is but little probability that it will ever return to its old figure. Moreover, we may suspect that the United Kingdom is moving towards the time when, even though coal lies in plenty beneath the earth, few men will be found to win it. As the mining class becomes better educated, as it is provided with more amenities in its home life, and as it is encouraged to enjoy refinement, its dislike for an occupation which was not distasteful to its forbears must of necessity increase.

We do not say it is not right that the standard of life of colliers should be improved. But let us not deceive ourselves. Improvement means the diminution of the class, for it is wholly inconceivable that men with refined tastes will follow the craft of the coal miner. Already they demand high wages and short hours; in the future, the not very distant future, not even high wages and short hours will suffice to induce more than a portion to remain in the pits.

Thus the economic position is changing and schemes which a few years ago were outside the pale of serious consideration fall now within its extended limits. Hence the Water Power Resources Committee of the Board of Trade, which at the moment is giving particular attention to the problem of power generation from the tides in the Severn estuary, will have to study the balance sheet in a new light, and we shall not be surprised if it takes the view that, costly as tidal schemes would be, and venturesome as the experiments might prove, yet there are sufficient reasons for making them.

Registration of British Civil Engineers.—A bill is to come before the House of Commons to regulate and establish registration for the civil engineering profession in Great Britain. The register as first established would contain: All corporate members of the Institution of Civil Engineers and of the Institution of Civil Engineers in Ireland; and other persons who are engaged as civil engineers and are members of important engineering societies; or who, although not members of such societies, have been engaged in civil engineering practice for a substantial period. For the purpose of determining the elegibility of engineers in the second group, a tribunal is to be established upon which the important engineering societies are to be represented.

Hydraulicking Earth

By C. A. JOHN HENDRY.

From a paper read before the Geological and Mining Society of India.

The flushing of anthracite coal mines with silt and fine rock or slate has been carried on in the United States for many years with great success. In fact the idea originated in the United States, and the method has been adopted with certain modifications by various other countries. British engineers term the process "hydraulic stowing," and the following article notes conditions prevailing at various mines in India where stowing is practiced.

Certain factors should be taken into consideration before a definite plan is decided upon in introducing hydraulic stowing in a mine and suggestions are here made as to the lines along which such preliminary investigations should be conducted.

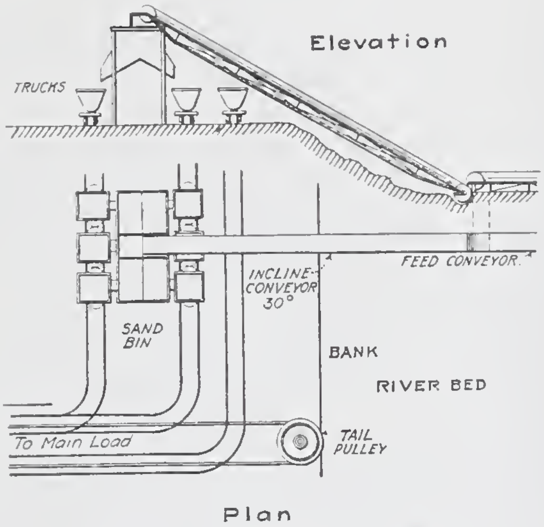


Fig. 1—Method of Raising From River.

Elementary Rules for Hydraulicking.—Looking at the matter from a purely hydraulic standpoint, the delivery of stowing hydraulically through a pipe is subject to the following elementary Rules: (1) The loss by friction is proportional to the length of the pipe; (2) it varies roughly as the square of the velocity; (3) it varies inversely with the diameter of the pipe; (4) it increases with the roughness of the pipe surface; (5) it is independent of the pressure. The introduction of some lubricating element in the stowing material, such as nodules of clay, is possibly well worth consideration for it would reduce wear on the pipes carrying the stowing material.

The coefficient of friction naturally varies with the velocity of flow and the diameter of the pipe. With a comparatively short pipe it may be necessary to consider losses due to elbows or bends in the pipe line. Where (as is usually the case) the length of the pipe is greater than 1000 times the diameter, the velocity head and the loss of head at the entrance need not be considered, for it is so small in comparison to the frictional losses as to be quite negligible.

Generally speaking, in long pipes we may ignore losses due to entrance, bends and variations in the pipe sections. The effect due to bends is of small importance compared with other frictional losses, and it is with these other frictional losses that we are chiefly concerned. If sand stowing, or packing, is to be carried out on definite lines, it will be necessary to find out the relation of head to length of pipe line, the ratio of sand to water and the velocity to the size of the pipe.

All these things will have a definite relation one to the other, and if the system is to be carried out on a large scale then it is desirable to collect information and to experiment so that a basis may be established for common use. It may be an exhaustive matter to derive suitable coefficients for all conditions, still there is no reason why the behavior of certain mixtures, such as one part of sand to three of water, should not have certain coefficients of friction worked out for them. Then the velocity (and therefore the rate of supply) can be determined; or the maximum length to a certain head can be derived and the cost of an installation and its capabilities can be worked out with some exactness prior to the commencement of the work.

Rough experiments have shown that the ratio of sand to water varies in direct proportion to the head and the length of the pipe, while the frictional coefficient is doubled when sand is introduced to the maximum carrying capacity of the water. Such results should be checked with pipes of a greater head and length; then we will find that the effect of a bend at the entrance will be less evident and the flow steadier. Roughly speaking, where the proportion of the head to the length is 1 to 5, then the proportion of sand to water will be about 1 to 3; or where the proportion of the head to the length is 1 to 3, then the sand to the water will be about 1 to 15. However, the capacity of an installation will depend upon the size of the pipes and the velocity of flow in them. It would be an advantage if experiments could be carried out in instances where systems were in actual use so as to determine the proportionate results with some degree of accuracy.

It should be remembered that there is a limit or the minimum velocity at which the mixture will flow; at velocities below this minimum the sand held in suspension will gradually increase fractional losses until movement of solids practically ceases. On the other hand, high velocities of mixtures result in abnormal and costly wear of pipes.

The wear on the pipe due to friction would vary with the proportion of sand to water—the more water used the less the friction. However, it should be considered that the more water used the greater will be the expense for pumping out the water after it had been used for flushing. It would be a nice balance of costs to determine which would be the most economical mixtures.

Character of Pipe-Line.—Regarding the character of the pipes to be employed we may consider: (1) Cast iron; (2) wrought iron; (3) wood; (4) terra cotta; and (5) porcelain lined. The shape in comparatively small installations would be circular, but ovoid pipes may be considered in special cases. In general it will prove economical to employ thicker cast-iron pipes for flushing lines than is usual in the case of pipes used for water only; in no case is it advisable to employ them under ½ in. in thickness, as the tensile strength is low and uncertain.

If, for economic reasons, cast-iron pipes must be employed, it is advisable to have them as thick as practicable. For instance, assume the outer diameter of a pipe is 7 in. and the inner 6 in., then the cross-section area of pipe metal would be 10.21 sq. in. If we increase the outer diameter of the pipe to 7½ in., and keep the inside diameter 6 in., then the section area would be 15.904 sq. in.; there would be an increase of 5.694 sq. in. in section. Thus, for scarcely more than half as much more metal, the life of the thicker pipe will be double as long as in the first case; this is true provided we assume the pipe will give trouble and have to be discarded when its thickness gets below, say, ¼ in.

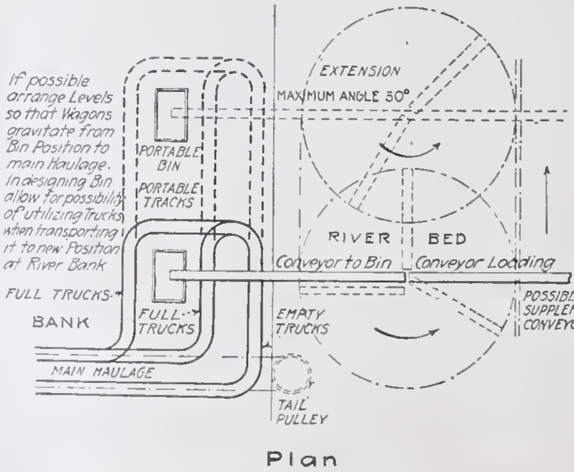

If possible arrange Levels so that Wagons gravitate from Bin Position to main Haulage. In designing Bin allow for possibility of utilizing Trucks when transporting it to new Position at River Bank
PORTABLE BIN
PORTABLE TRACKS
EXTENSION
MAXIMUM ANGLE 50°
RIVER BED
Conveyor to Bin
Conveyor Loading
FULL TRUCKS
BANK
FULL TRUCKS
EMPTY TRUCKS
POSSIBLE SUPPLEMENTARY CONVEYOR
MAIN HAULAGE
TAIL PULLEY
Plan

Fig. 2—Arrangement of Supplementary Conveyor.

Wrought-iron pipes are not particularly suitable for use on longitudinal lines, as their cross-section is comparatively small; they have, however, the advantage of considerable length, resulting in fewer joints, and their fibrous structure (if unriveted) offers less resistance than granular sections.

For underground pipe lines wood might be profitably employed in special cases. The pipes consist of a number of staves, their edges bevelled at an angle radiating to the center of the pipe and bound around at intervals with steel ties arranged with a take-up block to insure efficient tightening. The staves would be 1 to 3 in. thick, depending upon the size of the pipe. The pipe would be bulky and not generally adaptable. Pressures up to 200 lb. per square inch are possible, though 150 lb. would be a satisfactory maximum. With higher pressures it is likely that water would be forced through the pores of the wood.

The porcelain-lined pipe is possibly debarred by its high cost from adoption in cases where coal is mined and sold at a particularly low figure. It is possible that vitrified terra cotta may be suitable for underground use, as when vitrified it is coated with an impervious vitreous lining on which acids and alkalies make no impression. This is an important point, as in some cases a good proportion of the wear of pipes is due to the acidity of the water. It may be possible for interested concerns in India to devise means of materially increasing the vitreous lining to suit the peculiar conditions of use.

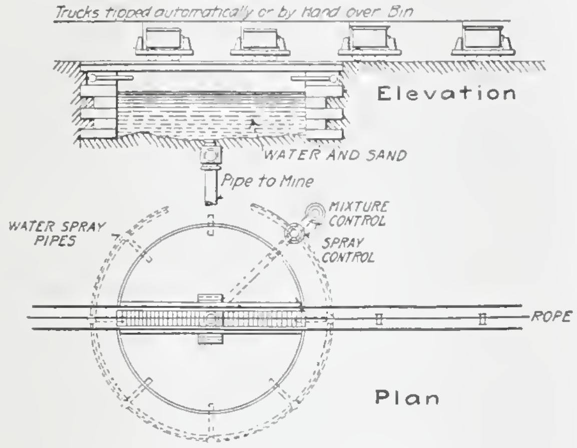


Fig. 3—Sand Receiving Bin Over Mine.

In all cases it will be advisable to arrange so that the pipe can be turned around, if desired, as the wear will be greater on its lower portion. Continental experiments have shown that steel pipes must be changed or turned over when 97,446 cu. yd. of material, made up of waste from the washeries, broken boiler cinder, etc., had been flushed through them; while the same attention was necessary after 56,506 cu. yd. of sand had passed through the pipes. With cast-iron pipes it was necessary to turn them over after the flushing through of 68,016 cu. yd. of waste from the washeries, or 59,906 cu. yd. of sand. The steel pipes in this case had a thickness of 5/16 in. and an internal diameter of 7¼ in. The cast-iron pipes had a thickness of ⅜ in. and an internal diameter of 5⅞ in.

Loading and Transporting Material.—The loading from the river bed will, in a measure, depend upon the method of transportation adapted to the mine. In any case it is safe to assume a severe gradient will have to be negotiated from the river bed to the bank. The work on the bed will in a majority of cases have to be of a temporary nature suitable for rapid removal and therefore a separate unit to the main pipe line. For this, light belt conveyors may be suggested, one or more horizontal ones on the bed and the other running up the bank, as indicated in Fig. 1.

The maximum angle at which sand can be dealt with would be about 30°, although certain patent types and scraper conveyors will, of course, deal with much steeper gradients. The horizontal feed conveyors should preferably be entirely self-contained, driven by a motor and capable of being moved around in a semi-circle with the lower end of the inclined one as a pivot (see Fig. 2). It would be necessary to fix it on rollers or skid plates to facilitate its circuitous movement, and it could be provided with a simple motor driving attachment for the purpose if necessary.

A steam shovel is likely to prove too heavy for the purpose of loading and a conveyor appears to be the most suitable. Should an aerial gear be employed for the transportation line another type of gear might be profitably substituted.

Assuming the case of mines adjacent to the river, with possibly plenty of water, the simplest form of transporting appears to be an endless haulage in conjunction with three-ply rubber and canvass conveyors. The plan would be practically automatic, and we might assume the following conditions: The sand would be loaded into a horizontal conveyor, and thence to an inclined one leading into a small loading hopper on the bank. From this it is fed into dump cars and these are moved by endless haulage over a bin; as the cars pass over the bin they are automatically dumped. From the bin the sand is washed into the mine. (Fig. 3.)

A constant supply of sand is by no means the least important matter when the tonnage becomes considerable. It might pay to have an inclined plane at the bank, have a supplementary haulage to the main one and run the dump cars on tracks on the bed of the river. A series of light tracks provided with flat steel ties could be used. This plan omits the conveyors and bin at the bank. (Fig. 4). Pumping the sand direct through a pipe line may be suggested; but it does not overcome any more successfully the problem of loading, while the effect of sand on anything with which it comes in contact is familiar.

Examples of Loading Plants.—It may be mentioned that the dredging plant at the Port Talbot docks included a sand pumping unit. This dealt with something like 150,000 cu. yd. of spoil material with a 22-in. pump and discharged it at a rate of 200 cu. yd. per hour, at a point 500 yd. from the pump. Possibly further investigations of the suitability of such a unit is warranted under certain conditions.

Another method may be considered where the distance to the mine is comparatively short and the sand area is situated on the far side of the river from the mine; the sand for flushing, under these circumstances, would be (for a certain period of the year) carried across the river. The scheme might be outlined as illustrated in Fig. 5.

A tower might be set up at some point on the river bank most conveniently situated for sand excavation. A combined conveyor and elevator possibly could be arranged to run from the river sand deposit to the top of the tower, running horizontally in the river bed so as to facilitate loading. At certain times of the year it could be shortened to avoid flood water and to enable the vertical section still to operate should sand be available. The elevator would discharge sand into a flume at a sufficient height above the receiving point at the mine to allow the material flushed with water to gravitate to the mine. The water for flushing would be pumped up a pipe supported by the same tower. The proposition would necessitate the use of a number of frames or intermediate towers to carry the flume at a suitable grade. The flume towers should be suitably braced to withstand wind pressure and the load, the former possibly proving the most serious consideration. There may be cases where it would prove more advantageous to employ a pipe in the place of the open flume, so that the head necessary to transport the sand may be reduced; this plan would allow water to enter the pipe under pressure thus preventing the settlement of sand in transit.

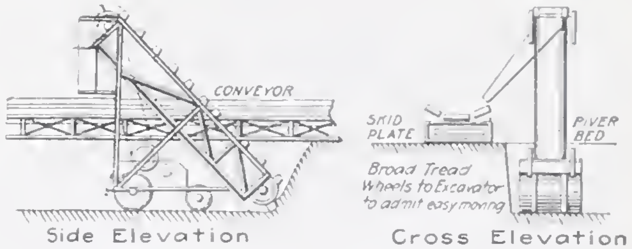


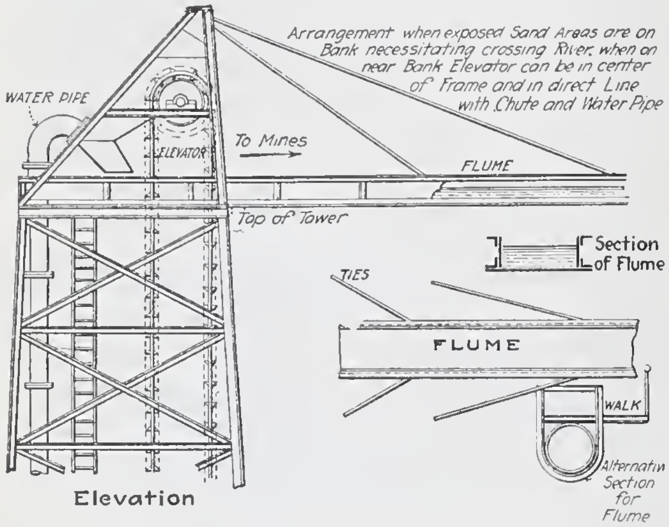
Fig. 4—Excavator for Loading Conveyors.

The scheme shown in Fig. 5 would only necessitate power to drive the elevator and necessary pumps. Further, in order to produce the necessary scouring effect the usual proportion of water to sand might be greatly increased. Having completed its work of transporting the sand to the mine, the water could be drained off and led back to the pumps by means of another flume.

Thus the water could be used over again. The sand could be allowed to settle in a bin adjacent to the borehole into the mine and the usual proportion of water added to carry it underground.

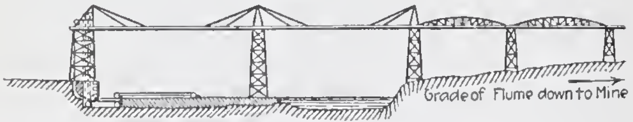
Hydraulic Features.—In considering a suitable coefficient of friction for flume troughs of various dimensions with varying velocities to suit conditions, it should be observed that the scouring power of a flow of water in an open channel does not at all times bear a direct relation to the velocity and depth. In other words, as the hydraulic radius is increased, it does not follow that in order for the water to impart motion to the sand the velocity of the water will increase proportionally.

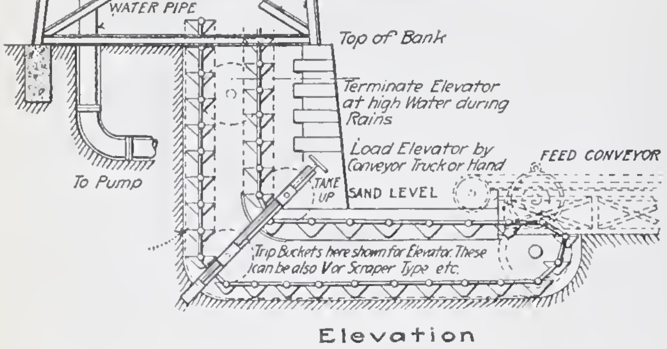
The depth of flow is an important factor, as the water first subjects the sand to a motion of dragging, and later the particles are lifted up into the stream, the motion being then converted into one of suspension. The water carries a larger quantity of sand in its lower portion than the upper, and generally it could be assumed that the amount is proportional to the depth. Regarding the wear due to friction of the sand on the pipe, it may be an advantage later to investigate carefully the relationship of this to the velocity. For it may be assumed that in pipes the greater amount of material carried will be along the center portion of the water; it remains to be determined to what economical limit the velocity of the water may be accelerated in order to increase the time of suspension of the particles and reduce the friction due to the dragging effect of sand particles.


Arrangement when exposed Sand Areas are on Bank necessitating crossing River. when on near Bank Elevator can be in center of Frame and in direct Line with Chute and Water Pipe
WATER PIPE
ELEVATOR
To Mines
FLUME
Top of Tower
Section of Flume
TIES
FLUME
WALK
Alternatin Section for Flume
Elevation

BANK TOWER FOR FLUME

GENERAL VIEW OF FLUME OVER RIVER




WATER PIPE
Top of Bank
Terminate Elevator at high Water during Rains
Load Elevator by Conveyor Truck or Hand
FEED CONVEYOR
TAKE UP
SAND LEVEL
To Pump
Trip Buckets here shown for Elevator. These can be also V or Scraper Type etc.
Elevation

BASE OF TOWER FOR FLUME AND SAND FEED IN RIVER BED

Fig. 5—Feeding and Tower and Chute Arrangement for Conveying Material Over River.

Where, however, the sand is washed into a bin and precipitated, while the water is allowed to overflow and run back to the pumps at the river bank, then the proportion of water to sand may be high so that the inclination of the flume or pipe-line can be reduced. Further, at the feeding point the tower can be extended to a greater height so as to increase the head, and this would reduce the requisite height of the other towers in the case of a pipe-line.

In the open flume it is doubtful whether a coefficient of friction for sand on iron will be less than one-fifth. Thus, for water to carry 1 lb. of sand a distance of 100 ft. requires 100/5 = 20 ft.-lb.; if the proportion of sand to water is 1 to 10, then 10 lb. of water must fall 2 ft. in 100 to give this energy. However, while the water imparts motion to the sand there is a tendency for the former to run at a higher velocity over the latter, so that the inclination of the flume should be more than 2 ft. in 100. Possibly for feeding the sand, in the place of the flume it would be better to employ a pipe, and we may then roughly assume that the grade will be in proportion to the mixture; if one part of sand be used to 25 of water the grade would be also in this proportion, or 4 ft. in 100. The necessary head might be increased at the feed tower, so as to reduce the height necessary for the intermediate towers. The flume bearing the return water to the pumps could be carried across the river (when necessary) below the supply pipe and on the same supports.

Excavating and Loading with Portable Machines.—In America sand is often excavated and loaded by portable machines consisting of a frame with a number of buckets fixed to an endless chain running over both head and tail wheels. The buckets are about 18x18 in. in cross-section, and the apparatus delivers about one ton per minute. The machine is equipped with a chute and only requires about a 7-hp. motor to drive it, the weight with the motor being about 7,000 lb. About eight of these machines would possibly help to solve the difficulty of labor trouble with regard to loading and prove more economical. The excavators at the river bed would then feed into a conveyer, and from experiments it is found that one man can load a conveyor with 6.75 cu. ft. of sand in 12 minutes with the material at a distance of 18 ft. from the conveyor. In practice the conveyor could possibly be moved in such a way that the men would be close to it all the time, and would at the most have to carry the sand about 3 feet. In the condition under review it was found that the 6.75 cu. ft. actually were deposited in the conveyor in 12 minutes, as noted. This represents 675 lb. in 12 minutes, or 1.6 tons per hour.

With a conveyor 500 ft. long and a man every 3 ft., 166 men could be employed each side of the conveyor, and these could load about 500 tons per hour; but for the purpose of calculation it would be advisable to figure on not less than 400 men.

Assuming the conveyor could be moved practically in a circle, we get a superficial area of 783,828 sq. ft.; or excavating to a depth of 2 ft., we would have about 1,567,656 cu. ft., equalling about 70,000 tons, or 14 days' supply. This conveyor then would feed into another one leading up the bank, the latter being 600 ft. long. Since the loading point at the bank is being continually shifted from the bank terminal of the main transportation system, a supplementary haulage would have to be introduced running parallel and close to the bank; a portable bin would have to be provided into which the conveyor running up the bank would feed. As the area was excavated in the river bed, and the conveyors were shifted, the bin would be moved from time to time to suit conditions. Owing to conveyors being more expensive than a track, the former is not to be recommended for feeding direct to the main haulage. The loading bin would have a capacity of about 100 tons (or 2,240 cu. ft.) and if it was 40 ft. long, would accommodate eight trucks at a time; this would enable loading at the speed required to allow them to leave at their 8-second intervals.

Water Supply for Troops in the Field.—In a paper in the November Journal of the Royal Engineers, Brig. General R. P. T. Hawksley states that the allowance per head should be: per man, 1 gal. per day; per horse or mule, 10 gal. per day; per camel, 20 gal. every third day. The allowance per man and horse may, for certain definite purposes and over very short periods of a day or two, be reduced to ½ a gal. and 5 gals. respectively, but as a rule both should be provided with as much water as they require, within reason. The theory that men and horses can be trained to use a very small amount of water is not a sound one. It is better to start an operation with men and horses in the pink of condition than in a half-starved state. Therefore, in arranging for troops at rest, the amounts should be considerably increased. But when this is analyzed, the increase, except in very hot weather, when a horse may drink some 12 gal., or even more, is due to the requirements of men only as regards washing, disinfection of clothing, and similar purposes.

The Making of an Engineer

From The Surveyor, London, Nov. 11, 1919; part of the inaugural address of Sir William Ellis, M. Inst. C. E., President of the Yorkshire Association of Students of the Institution of Civil Engineers.

In all professions the success of a member depends on possession of special attributes necessary to such a profession. This is especially so in the case of the law, medicine, and some others I could mention. With engineering, however, the subjects covered are so wide that, given strength of character and determination, men of ordinary ability need not fear to choose it as their profession. We find, on looking back to apprenticeship days, that of the many who started in the race, only a few are still running. This, I venture to say, is not because those who have fallen out lacked the ability to equip themselves, but rather because they more often did not possess the power, perseverance and determination of character without which no success can be achieved in engineering.

In dealing with this question of "How do we become engineers?" I am aware that training for a successful engineer is different in the case of the large number of students taking up mechanical engineering from what it is in other branches such as civil, municipal, or mining engineering, and in the short time I can allow myself to speak to you I want to make it quite clear that I am confining myself to the questions of suitable training in the widespread branches of mechanical engineering, and not attempting to deal with the most desirable training for other classes of engineers.

Workshop Training.—We are all of us aware that practical training and theoretical training are both of them essential to success as a mechanical engineer, and the very vexed question is constantly in our minds as to which horse is to lead in this tandem of training. I should like to ask whether there are any particular reasons, making the sequence in which these two are taken, important as affecting either training adversely. Personally, I answer the question in the affirmative. Unless a boy undertakes the practical training before the age of twenty-one he is prevented from mixing with the workmen and sympathetically understanding their views of life while he is still a boy. It is true that it is possible to obtain certain practical training after the university course has been embarked on; but then the student meets the workman as a man with men, and they naturally view his efforts in a different manner from those of a boy.

Forty years ago, when I started my apprenticeship in Leeds, it was considered necessary for a boy to go into the shops for the purpose of learning to plane, turn, fit, etc., and to familarize himself with the output of the various types of machines. Today this is also the case; but in my opinion this is not the primary object of a boy going into the workshops at the commencement of his engineering career. We are all of us aware of the great difficulties which exist in connection with the desires and determinations of the various trades unions, and any employer will bless the fact, in after life, when he has to deal with these problems, that he had the opportunity—I would almost say privilege—when a boy of working with the men in terms, I may say, of personal intimacy and friendship. This will have taught him to understand the workmen and to sympathize with them in their hopes and fears in a way which is quite impossible in the case of any employer who has not had such opportunities.

The University Period.—I would urge most strongly that whatever course is adopted the greatest attention should be given to arrangements whereby the student should have opportunities early in life of understanding the difficulties which present themselves to the mind of the average workman. On leaving school at the age of seventeen or eighteen it is usual for a boy to have obtained a sound general education. In most cases if that boy goes forward directly to a university for the purpose of taking up special engineering subjects he finds himself faced with the fact that the education he has acquired at school, being of a more general nature, does not bring him up to university standard on special subjects. Assuming, therefore, that a student has embarked on a practical course of training on leaving school, the period before he goes forward to the university can be most beneficially used by taking up evening work on the special subjects which will equip him, on a university standard, for the particular course he is proposing to take up at the university later. From a university standpoint I am quite conscious that when a boy leaves school with a trained mind he is very much easier for a professor to mould and turn than when after possibly two or three years' practical work he comes into his hands with somewhat less scholarship or with a less scholarly mind. On the other hand, I would ask the professor to realize that a boy who has had some practical training will come into his hands with a better grasp of the practical application of the subjects, the scientific side of which he is going to study at the university. The boy may be better able to understand the reality of the scientific subjects with which he is dealing because he has already seen something of their practical application, and it is for these reasons that I urge the full consideration of the importance of the sequence of the boy's training. In the case of boys going forward to the university to take a degree course after only about two years' practical training, it is desirable to most cases for them to return to the firm where they commenced their training so as to gain experience in the drawing office, and possibly further practical experience, and in the event of students having done well at the university there is little doubt that firms will be quite willing to allow them to return to complete their training on completing their university course.

I would urge all students to realize that to become an efficient engineer a great spirit of perseverance and determination and even of self-denial must be cultivated.

In earlier years, even at school, I used to feel very apprehensive because so many of my boy associates possessed much greater scholarship and mental ability than I did. Indeed, all through my life I have been conscious of such disabilities, but I have also realized that nature is extraordinarily kind to most of us. If we are not equipped with one or another of the special attributes which we think would be of great use to us in our particular walk in life, we probably possess some other characteristics which are sufficient to enable us to find our way through life, and with energy and perseverance to reach a reasonable rung in the ladder of our profession. Health and strength of character are much more important to an engineer than cleverness in mathematics and science generally. The power of disregarding our own convenience when it clashes with the duty we owe to those who employ our services must be a characteristic of any successful engineer through life.

Work and Play.—I would also urge upon the young engineer the importance, towards the end of his training, of taking opportunities of doing work in other countries. The mere fact of being away from home on his own responsibility tends to strengthen self-reliance and general character, and I would almost insist that it is an important part of a young engineer's training. Some of you may feel that I have pictured engineering to you as a very serious course of life to adopt. I have always felt that it was so, and realized that no success was possible in engineering without regarding the training for it, and the close application to it in life, in a very serious manner. In order, however, to succeed on this serious path I would attach great importance to maintaining that love of active exercise and games which we all acquired at school. No one will succeed in life who does not view from a proper standpoint the relations of work and play, and playing in moderation and at the right time is quite as essential to success in work as anything else.

Happily, in the various works more attention is being given to providing facilities for cricket, football, swimming, and welfare consideration generally, and at the universities, students' associations, clubs, etc., exist for the same purpose. I would say to all of you, take every opportunity of judiciously mixing up work and play. I should like to give the same advice to men of my own age also, for although we cannot take part in the games as we used to, it is absolutely essential to cling to both a physical and an intellectual hobby as years creep on us if we are to carry our load of responsibility with the health and light-heartedness which are, in my opinion, essential to success.

Opportunities of the Future.—I would ask you, then, to think over carefully these questions. Is not engineering, considering its wide application for the comfort and development of the world, a noble profession to embark upon, and ought we not to be proud to fill our own little corner in the world by being allowed to turn our minds to a subject of such varied interest? Cannot we all do our little bit in adding to the great development which engineering has brought about in the world? I think we all ought to be proud to be allowed to take our share in this great work. Is it not our bounden duty and also our pleasure to devote six vigorous years of our early life for the most efficient equipment we can find to enable us to deal with the great problems surrounding the life of an engineer. Our opportunities today are undoubtedly greater than in earlier years. For one thing the literature and text-books of the present day on engineering are so numerous that almost every branch has its own efficient literature; and then again we are able to travel and by observation to see the magnificent work already carried out by members of our own profession, and surely this will have a most stimulating effect on us.

I would like to point out to the students of this association the wide opportunities for useful work that are before them. We deplore the loss caused by the many promising young engineers who have given their lives for the country, and in addition to these losses the profession has been depleted by so many students taking active service in the war and deciding not to resume, either on account of age or other circumstances, engineering as their profession. The result of these facts is that there must be for some years a dearth of young men of good training ready to take up positions of increasing responsibility, and you are therefore embarking on your career with far less competition than is usual. In addition to this, the war has delayed new schemes being put into operation all over the world, and as soon as financial matters become more normal there will be great developments in all directions. I therefore feel that those of you who are now equipping yourselves for your profession have splendid opportunities before you.

British Experiences With Reinforced Concrete Roads

By W. MATTHEWS JONES.
City Surveyor and Engineer, Chester.

From Engineering, London, Nov. 28, 1919; abstract of paper read Nov. 21 before the County Councils' Association, at the Roads and Transport Congress.

I find it somewhat difficult to put into words all that I should like to say with regard to this class of road construction, inasmuch as opportunity of actual experience has been limited, and the knowledge which other surveyors and myself have obtained has chiefly been acquired by reading papers which have either appeared from time to time in the engineering press, or have been read on the subject in America. However, I hope that my paper will at least initiate a discussion which will throw ne[illegible] the matter and that some good purpose will thereby be attained.

Some 9 or 10 years ago a road widening in Chester had to be done, and it occurred to me that this would be an opportune time to try a concrete road surface. Accordingly, with the permission of my Highways Committee I laid an area of about 400 sq. yd. of concrete. This was not reinforced, and was opened out a fortnight after completion. The surface has stood exceptionally well as a surface, but owing, in my opinion, to it having been opened for traffic too soon and to the lack of reinforcement, it became wavy and bumpy, although it did not actually break up. The whole area was laid 8 in. in thickness, and was on a clay subsoil. Two months after being opened for traffic I was afraid (owing to the waviness) of its breaking up. I therefore covered the surface with tarred chippings. This, in my opinion, obviated the breaking up, although the tarred chippings also become wavy, but not quite to the same extent as the concrete underneath. However, I think that in the circumstances this first experiment stood well, and today the surface is not in a bad condition.

The second experiment I carried out was on a main road leading into the town and taking about 700 tons of traffic a day. Perhaps this experiment will not be considered a fair test, but it must be understood I am only giving my experiences. The lengths laid in this case were reinforced; they were 5 ft. wide each and about 50 yd. in length; each strip was placed between the tramway margin setts and the curb forming the footways. My reason for trying this system here was because I found that neither water-bound macadam nor tar-macadam would stand, and I was continually having to repair these narrow strips. The reinforced concrete surface has stood exceptionally well, and has been down for about seven years. I tar-spray this concrete once a year—if I happen to be in this district with the tar-spraying machine I do it twice. The tar-spray is afterwards covered before it is dry with ½-in. granite chippings.

In the third case, my committee decided, 7 years ago, that one of the streets in the center of the town should be repaved with wood blocks as the old ones were worn out. The wood blocks were taken up and the concrete foundation exposed. This concrete seemed to be in perfect condition, and I therefore discussed with my assistant the question of concrete carriageways. His reply was that the concrete would crack and break up under any weight of traffic. However, I determined to make an experiment and sent the 12-ton steam roller down the next day, marked out two lines along the center of the concrete and allowed the roller to traverse up and down 200 times; this meant that 2,400 tons passed over that particular area of concrete without the slightest sign of a fracture being observed. Again my assistant was not satisfied, and suggested that the trial of a vehicle with broad rims like a steam roller was no proof of the effect of a vehicle with narrow steel rims. I agreed, and as a further experiment the next day sent my 1,000-gal. tar-spraying machine (loaded) down to the work. This machine, when loaded, weighs approximately 10 tons, and has to be drawn by the steam roller. It was sent up and down the same track as that used by the roller on the previous day, and again I found there was no sign of cracking or breaking up. The steel tires of the tar machine are 4½ in. wide. This experiment convinced me of the suitability of concrete as a carriageway surface.

About this time the corporation had served notice on the frontagers under the Private Street Works Act, that a certain road in the district, known as Robert's Lane, should be repaired and put in order, the estimated cost of the work being £1,500. The owners and frontagers objected, however, to the work being done at this cost. I then determined to make a bold bid for reinforced concrete road carriageways, and submitted fresh estimates to my committee showing that I thought the work could be done for £960. This scheme was placed before the owners and frontagers and agreed to. The work was carried out for the estimated figure, and, although taking only about 100 tons to 120 tons of traffic per day, this road has given the most complete satisfaction, and is as good today as when it was laid. This carriageway actually cost 5s. 1d. ($1.22) per square yard per superficial yard, and the maintenance has, during the past 6½ years, cost the corporation on an average, 1½d. (3 ct.) per superficial yard per annum, this being for tar-spraying the surface and covering with chippings. After this I tried one or two small areas in side streets, with the same result.

White Friars was the next carriageway treated, and here again the work was successful, but it was for light traffic only. The cost of this work came to 6s. 3d. per superficial yard.

My Highways Committee have been so satisfied with these works that they are now allowing me to lay a reinforced concrete carriageway right through the main thoroughfare of the city. This street takes all the through traffic from Manchester, Warrington and Liverpool to North Wales, and I have roughly estimated that there is not less than 1,500 tons of traffic passing over this roadway each day. Along the center of these streets, is a double line of tramway track, and this is being concreted in it the same time. A portion of the work has been completed and opened for traffic, and up to now the results have been all that I anticipated. Of course, 3½ months' wear is really little to go by, but I have the greatest faith in this work being a complete success. Very careful observations are being made of the work, and in the event of its proving a failure I shall be able, from the statistics obtained, to find the cause and so remedy it in the future. I might add that we received the sanction of the Local Government Board to do this work, and I am happy to say that the Road Board have shown their interest in the experiment by granting my council the full estimated amount for carrying it out, viz., £5,000. I estimated for this work last January, at a cost of 11s. 3d. per superficial yard, but up to now the cost has been 12s. 9d. per superficial yard; this is owing to the price of cement going up 8s. per ton, granite 1s. per ton, a slight increase in the cost of labor, and also to a strike of the men engaged on the work.

If this scheme proves a success I shall ask my committee to allow immediately 8 miles of my roads, which at the present time require reconstructing, to be done in a similar manner. It may be interesting here to say that if the 8 miles of roads are reconstructed with reinforced concrete I estimate the cost will be 13s. per superficial yard, making a total of £82,368. If the work were done with granite sett paving on concrete foundation I could not in Chester estimate a lower cost than 25s. per superficial yard, or a total of £158,400, or, again, if it were done with tar-macadam, including a foundation, 17s. per superficial yard, or a total cost of £107,712.

From these figures it will be seen that a reinforced concrete carriageway shows such a saving that if we can only construct these roads on right lines no other method will, in my opinion, stand a chance.

The concrete is mixed in the proportion of 5 to 1. The granite used is of the following sizes. 1½ in., 1 in., ¾ in. and ½ in. These are mixed in equal proportions, as I have come very firmly to the conclusion that it does not do to lay the larger material in the bottom and bring the finer material to the top. The secret in reinforced concrete road construction is, to my mind, to have all the interstices filled; one must have no voids, and I believe that by the mixing of the different sizes we get a perfect mass of conglomeration of the matrix, which is as necessary in a road as it is in a concrete floor or beam. The proportions of the concrete are 3½ of granite, 1½ of clean sharp sand to 1 of cement. The sand must be perfectly clean and free from clay or soil. The cement must be of the best quality to be obtained and medium setting, and in this respect I have been helped by the manufacturers supplying it; they have given me every assistance to get the right material. The reinforcement used is that of a well known engineering firm. When the concrete surface has been completed—that is, after it has been trammeled to the contour and allowed to set, I tar-spray the surface and cover off with ½-in. granite chippings.

This concludes my account of the work I have had in hand in Chester, and I now propose to touch briefly on works carried out by other surveyors so far as my knowledge extends.

Gravesend Reinforced Concrete Road.—It will be remembered that between December, 1914, and March, 1915, Mr. H. T. Chapman laid an experimental length of reinforced concrete road near Gravesend, the subsoil of the district being chalk. The concrete was mixed in the proportions of 6 to 1, and the road takes at least 1,000 tons of traffic per day. For national reasons it was impossible to close the roadway to traffic, so it was decided to do half the width of carriageway at a time and allow the traffic to use the other half whilst the work was in progress.

The work was carried out under abnormally bad weather conditions. I am told that frost prevailed on many days; when there was no frost, more or less rain was coming down, and everyone who had made a study of this class of road construction therefore came to the conclusion that it would be a wonder if this road stood at all. Events proved that it did not stand, and that when the traffic ran over it the surface soon showed signs of wear and tear, and many holes appeared. The bad places were hacked out and tar-macadam laid on. In spite of this questionable failure, Mr. Chapman, however, decided to commence work on the other half of the carriageway, and on this occasion he was favored with better weather conditions. He also adopted a different method of construction, for instead of putting the full 6 in. in depth of concrete with a 6 to 1 mixture, he laid the bottom 4½ in. with 6 to 1 and the top 1½ in. with a richer and finer mixture, viz., 3 of grit and sand to 1 of cement. This second portion, which has now been opened for traffic since, I believe, 1915, is as good as it was the day it was laid. This latter method of laying two-coat work is naturally more expensive and tedious than the mixing and laying of the concrete in one body. I am quite convinced, however, and I think Mr. Chapman will agree with me, that if the work of the first half of the roadway had been commenced, say, in March, 1915, instead of ending then, the whole roadwork would have been a great success. However, as I have said, Mr. Chapman has given us all an experience and taught us that concrete roadways should not be laid in winter.

Other English Concrete Roads.—Mr. S. A. Hill-Willis, surveyor to the Tilbury, Urban District Council, in 1916 laid a trial length of reinforced concrete road on a soil of alluvial drift 40 ft. deep before reaching firm ground. It has over it daily more than 250 vehicles, in addition to motor vehicles and tractors, the pre-war census of these being 89 daily. This trial section was laid on the main road leading to the Tilbury Docks, and all traffic in and out of them has to pass over it. A few months ago I had an opportunity of inspecting this road, and the surface appeared to be in perfect condition. On inquiry, I found that the actual maintenance cost since construction had been nil. I should also like to add that when walking from Tilbury Station towards the work, the reinforced concrete portion is noticeable at a distance of at least 200 yards. It seems to stand out conspicuously as a level stretch of road surface and, when compared with the ordinary macadam surface at each end shows, to my mind, the great advantage of concrete.

At the beginning of the war, the government built a large military camp at Chiseldon and constructed over 2 miles of reinforced concrete road foundation, on which it was intended to impose some type of wearing surface. The military authorities, however, eventually decided to run the traffic directly on the concrete. Nothing has been spent on the road, it has borne very heavy traffic, and it is in good condition today, while other roads in the camp have had to be practically remade on several occasions. I saw these roads, while under construction, on two occasions, and was fully convinced that they would give satisfaction.

In Dunfermline, Mr. P. C. Smith, the late surveyor, reconstructed a street with reinforced concrete surface, replacing setts on a clay foundation. The width of this thoroughfare was 15 ft. 6 in., and the length about one-third of a mile. The only expense in maintenance since reconstruction has been about £1 per annum for tar-spraying. The heavy traffic over this thoroughfare consists of the naval base traffic to Rosyth, as well as the ordinary town traffic, together with a motor-bus service, and on making recent inquiries I was informed that the surface is in really good condition.

Cutting Through Reinforced Concrete Paving to Secure Access to Underground Utilities.—With reference to the statements often made by water and gas companies, as well as by contractors and others, that a reinforced concrete road prevents easy access to mains and sewers, and that it causes extra labor to excavate, it is interesting to note the following case quoted by Mr. Bendall:

"In 1914 a certain gas company brought an action against a certain local authority who had laid down a reinforced concrete road foundation, claiming that by so doing it put them to extra expense getting to their mains. The judge who tried the case ordered a test to be made between plain and reinforced concrete.

"On Nov. 3, 1914, acting on the judge's instructions, Messrs John Mowlem & Co., Ltd., a large firm of London contractors, laid two sections, both being an area of 12 ft. superficial. One was of plain concrete, 12 in. thick, the other was reinforced concrete 6 in. thick.

"The reinforcement was placed about 2 in. from the bottom and consisted of B. R. C. fabric, having wires of 10 and 5 gauge. The concrete was a mixture of 6 to 1, and when both sections had been completed to nearly the thickness previously mentioned, a ¾ in. floating was made with cement mortar. This experiment was to determine the relative time to break holes of the same dimensions through each type of concrete. On May 11, 1915, five men started at 3:10 p. m. on each section to excavate holes, the dimensions being 3 ft. 2 in. by 2 ft. 2 in. Fifty minutes later the hole was completed through the reinforced concrete portion, while other five men had not finished their work through the 2-in. section unreinforced. The concrete was made with an excellent quality of Thames ballast. The reinforcement in the reinforced section was cut with a cold chisel and did not give any appreciable trouble in breaking it up."

With a view to showing the comparative strengths of reinforced and unreinforced foundations, I have been supplied by the British Reinforced Concrete Engineering Co. with the following figures for the "resistance movement" per foot width: Concrete, 6 in. thick, reinforced with No. 9 B. R. C. fabric, 13,000 in.-lb.; the same reinforced only 4,000 in.-lb. Concrete, 9 in. thick reinforced with No 9 B. R. C. fabric, 23,000 in.-lb., the same unreinforced only 10,000 in.-lb. Six inches of reinforced concrete is therefore equal to between 9 in. and 12 in of concrete unreinforced.

Methods of Constructing Reinforced Concrete Roadways.—Having said so much, I propose drawing my remarks to a close with a few observations as to the methods which should, in my opinion, be adopted by surveyors who are about to construct reinforced concrete roadways

1. Whenever it is intended to lay a reinforced concrete carriageway, the engineer or surveyor to the council should give six months' public notice in the press of his intention, so as to give property owners on each side of such street an opportunity of having their gas, water, electricity or drainage services examined and, if found faulty, put right.

Further, I strongly advise that whenever such services are examined, no charge should be made to such property owners for street repairs or maintenance from the time they have opened such roadway till such time as the surveyor commences his work. The upkeep and maintenance should be borne by the council, as I believe this does encourage examination and putting in order of the various services. Notice in writing should also be served on the water, gas and electrical engineers of the town.

2. If a new street is to be formed it should be arranged wherever possible that gas, water and electric mains should go down the footpaths, and wherever a pipe, line or electric main crosses the carriageway, they should be laid through stoneware pipes of sufficient diameter to allow (in case of bursts or escapes) of such pipe or cable being drawn from one footways to the other and so save breaking up the carriageways.

3. Drainage of the road bed is vital and should not be neglected and thought of no consequence.

4. The subsoil should be of uniform density and should be thoroughly consolidated.

5. The aggregate used must be clean, hard and tough, and free from foreign matter.

6. The fine aggregate (sand) should be coarse and well graded.

7. A rich mixture must be used.

8. Materials must be accurately proportioned, gauge boxes to suit the proportions should be accurately made, or if the mixings are done by weight then correct methods of weighing should be observed. Too much caution cannot be observed in carrying out this instruction.

9. Mixing must be thorough. If by hand, not less than twice dry and three times wet. If small areas are to be done it would not pay to mix by mechanical means.

10. Sloppy concrete must not be used. This is entirely a matter for the resident engineer or supervisor on the work to determine, as much depends on weather conditions prevailing at the time of laying. (I might add that whenever I start work of this kind I always spend the whole of the first two days on the spot to see that my requirements are properly carried out and that whoever is in charge on my behalf will be fully conversant with them.)

11. Reinforcement is necessary, and not only strengthens the concrete but prevents to a very large degree cracking of the concrete.

12. Supervision must be intelligent and thorough. I would also add constant, for I can assure anyone undertaking concrete work of this character that it certainly pays to have a conscientious assistant from the office or a reliable person in charge who will see that every mixing is properly gauged, turned over and laid. My practice is that not a mixing shall be done unless someone in authority and on my behalf is present.

13. Concrete must be prevented from drying rapidly. If this is not done it will be found that the upper surface, owing to either sun or wind, will dry more quickly than the lower portion. It is therefore advisable after the first 24 hours to water the surface of the concrete by means of a fine rose from a watering can as often as it may be thought necessary, the watchman on the work doing that at night. I do not agree with covering the concrete over with wet sand and keeping the same damp.

Up to now I have found that, speaking generally, using a medium setting cement, it usually requires four weeks for the concrete to set before it is ready for traffic to go over the surface.

If the foregoing conditions are observed in the laying of reinforced concrete roadways I am of the firm opinion that we shall have few failures in this country in carrying out our work. Careful observations should be made as to weather conditions whilst the concrete is being laid, and a note taken of any other incidents that may appear to be trivial at the time but which may give us information as to the cause of any failure.

I should like to add that in my opinion a reinforced concrete roadway properly made is today the most efficient and economical—it is waterproof, it is the most sanitary road that can be constructed, it is practically dustless in summer and mudless in winter, it reduces scavenging costs to a minimum and is practically non-slippery.

Plane Tables and Field Sheets

By BT. LT. COL. H. ST. J. L. WINTERBOTHAM.

From the Royal Engineers' Journal, November, 1919.

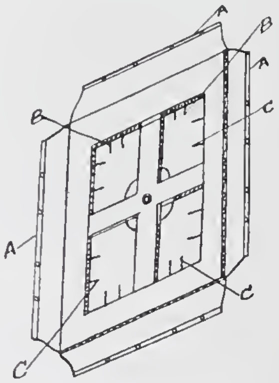
The distortion of the "field section" or "field sheet" due to changes of humidity and temperature, has been a thorn in the side of the topographer for many years, neither does there appear to be any means of eliminating it as long as the field sheet is of paper, or Bristol board, mounted upon a wooden board.

Bristol boards, although they generally show no distortion, if they are free to move, yet do expand. For reproduction this would not be serious, but for the comparison of mutual edges it remains a drawback. Moreover a Bristol board increases the weight. In view of these two objections, experiments were made in 1913 with linen backed paper mounted on aluminium or zinc. The coefficients of expansion of both these metals are so small as to be negligible for any ordinary range of temperature.

The points which were aimed at in the production of a mounted field sheet were:

1. Elimination of distortion.
2. Permanency—so that the finished field sheet should constitute a reliable record of the work done.
3. Adaptability to any of the special plane tables designed for it.
4. Lightness.

The two metals have about equal claims under 1, 2 and 3, but aluminium is much the lighter and its slightly larger cost is negligible in comparison to the value of the finished field sheet. Aluminium was therefore chosen. It was at first thought that the actual field work could be done upon a grained aluminium plate, and the experiment was tried. Although not altogether unsuccessful the experiment proved that an aluminium surface is undesirable for the following reasons:



Board Viewed From Below; Field Sheet Laid Ready for Fixing.

AA—Strips of aluminium mounted in the edge of the overlaps of linen and with holes at intervals to fit.
BB—Fixed hooks......... } fixed in the depth of the scantling
CC—Spring hooks........ } of the skeleton top.

1. It is too easily destroyed by dirt and by friction, and will not stand much erasure.
2. It becomes unpleasantly hot in warm weather.
3. It is not easily secured to the table.

Paper can be secured firmly to grained aluminium and the combination remains sensibly constant for normal ranges of temperature. The next experimental field sheet was therefore made of paper pasted or glued to aluminium, but it was found that the edges curled up enough to interfere with the sight rule.

It became necessary, therefore, to strain the field sheet down upon the table by springs, or lashings, and this was simplified by fixing linen on the aluminium with overlaps projecting beyond all four edges. The paper was then mounted on the top of the linen. Field sheets so constructed have proved satisfactory.

The weight of this field sheet is about 1 lb. more than that of linen-backed paper of sufficient size to mount the board. In some surveys this extra 1 lb. would be a handicap, and it seemed possible to save it in the weight of the board. Aluminium (of 30 gage) supported at small intervals on wooden battens, is sufficiently stiff to bear the weights of the alidade and Indian clinometer, and the pressure of hand and pencil. A skeleton board was therefore made, and proved to answer very well. It is described on page 116 of the "Text Book of Topographical Surveying."

The first design was somewhat too elaborate, however, and during the first trainings of 1914 experiments were made to find a simpler pattern. That which proved most satisfactory is illustrated.

The weight of this board mounted with an aluminium field sheet is compared with those of a board mounted with linen-backed paper, and a Bristol board, respectively, in the following table:

Description, size 24 in. by 18 in.	Total weight.
New board and aluminium field sheet	4 lb. 7½ oz.
Plane table, R. E.—board with linen-backed paper	4 lb. 12½ oz.
Plane table, R. E.—board with bristol board	5 lb. ½ oz.

The pattern of board described above can be fitted to the legs now in use for the "plane table, R. E." There are, however, no arrangements for a slow motion in azimuth on these legs. Indeed the feeling of many topographers is averse to the introduction of anything in the nature of a "gadget." In those countries where most of our plant table work is done breakdowns may be fatal. Experiment has proved, however, that a simple but ingenious arrangement can be fitted to the existing pattern of legs which provides a slow motion, thrown in or out of action by a cam, and detachable at will. It was tried in 1914 and unanimously approved of.

Another small modification which proved valuable was the introduction of one collapsible leg for each table. They are quite stiff when clamped, add little to the weight, and enable the table to be leveled on steep ground without undue splay of the legs. As each leg is detachable and is generally packed separate from the "top" the inclusion of a small number of legs of this pattern in the survey outfit will not necessitate their use if found undesirable, but will provide for a probable want.

It occasionally happens that topographical work is based upon a graphic triangulation, or that the two are done concurrently. The importance for graphic triangulation of a field sheet which will maintain its size, not only relatively, but also absolutely, is self-evident. For work of this nature a special plane table has been tried with a board of 24 in. square. The field sheet and board are designed on the same principle as described above, but made stronger to support the additional weight of the telescopic alidade. The board is leveled by a ball and socket joint made of aeromin.

New Rock Tunnelling Machine

From the Surveyor, London, Nov. 7, 1919.

Mr. Robert H. Bicknell, M. Inst. C. E., of 16 Victoria St., London, has recently invented a machine which he claims will bore circular tunnels through the hardest rock, by means of specially constructed hammer tools actuated by that wonderful discovery "Sonic waves." These waves are able to give the exact force and rapidity to the abraders which is required and which is obtainable by no other means. The abraders will be placed on five rotating arms driven by a Sonic motor. The abrading tools will strike the face of the rock at the rate of 3,000 blows per minute, each blow having a weight of 1,120 lb. By this means the whole face of the rock is abraded by each arm to a depth of ⅜ in.; thus with the five arms 1⅞ in. will be excavated at each revolution. The speed of the periphery abraders is 6 in. per second, so that in a tunnel 12 ft. in diameter the machine would complete a revolution in about 72 seconds. Accepting these data as a guide to the possible speed of abrasion, it will be found that an advance of 94 in.—or 7 ft. 10 in.—should be obtained in each working hour, or 282 lin. yds. per week.

Mr. Bicknell claims that by using Sonic wave transmission he is able to obtain 95 per cent efficiency with his abraders.

The Sonic generators are driven by electric motors.

The steel abraders can be changed as they become worn, and it has been found that the wear on them is so small that the machine will be able to be kept in useful operation for three hours without changing them.

Owing to the war it has not been possible to build a complete machine, but on several occasions recently parties of civil and mining engineers have seen one of the Sonic abrading tools attacking the face of a huge block of the hardest granite. The result of these trials has borne out Mr. Bicknell's claims, and it is believed satisfied the engineers who have seen the tool at work that circular tunnels in hard rock will in the future be able to be driven at a speed and cost that by present known methods is impossible.

Effect of Calcium Aluminium Sulphate on Concrete

From Beton u Eisen

Calcium aluminium sulphate is formed when a concrete contains free lime, alumina and any soluble sulphate, but may be produced by adding a solution of aluminium sulphate to lime water. When it is produced by the action of a sulphate on cement the highly hydrated crystals rapidly fill the pores and frequently cause the concrete to crack. If free lime and alumina are removed or rendered inert the double sulphate cannot be formed and a stronger concrete is produced.

The action of calcium aluminium sulphate on concrete was compared by Michaelis to that of bacilli on animal organisms and consequently it received the name of cement bacillus, but this is only a whimsical term, and so misleading that it should be abandoned. The crystals are only stable in the presence on water almost saturated with lime. Pure water decomposes them, dissolving the lime and calcium sulphate produced, and leaving the alumina as a white flocculent residue. The crystals are still more rapidly dissociated by solutions of salts or acids, and by sea water, and sea water appears to prevent the formation of the crystals in concrete.

H. Nitzsche has recently suggested that the probability or otherwise of a concrete being damaged by the formation of these crystals may readily be tested by treating a cement or powdered concrete with a sulphate solution or with water suspected to contain ingredients which may cause the formation of the double salt. The relative harmfulness of the cement, aggregate, water or solution is judged by comparing the crystals produced during a week when it and various standard solutions are added to a standard cement. No crystals of the double salt were produced in a long series of such tests using either natural or artificial sea water, nor were they found in test mortars which had been immersed for a prolonged period in sea water. Consequently, the destructive action of sea water on concrete must be referred to other causes, and not to the sulphates present.

The destruction of concrete by limited quantities of groundmoor or drain water, sewage or sulphate solutions may be attributed to the formation of the double salt and such fluids should therefore be kept away from concrete structures. Crystals of calcium aluminium sulphate have also been found in many samples of concrete and mortar taken from structures exposed to the action of sulphate solutions, these crystals being readily observed if a small piece of the dry material is broken and examined under a microscope having a magnification of 50 to 100 diameters. The crystals are not formed in decomposed or weathered material, but only in that which has not been unduly exposed to the weather or water. The existence of a white aluminous film is an indication of the condition being unfavorable to the existence of crystals of the double salt.

In cements, concretes, and mortars which are exposed to large quantities of water the crystals cannot be formed, as the quantity of water would make the lime solution too dilute. On the other hand, a very dilute solution of a sulphate will, in time, destroy a structure exposed to it, if sufficient lime is present in the cement or mortar to prevent the dissociation of the crystals.

The best means of preventing the destructive action of the double salt are of two kinds: (1) By the use of concrete of such a nature that the harmful fluids cannot penetrate it, and (2) by the use of resistant materials in the concrete. The first method consists chiefly in closing the pores of the concrete by exposure to carbonic gases, so as to effect the carbonation of the free lime in the material, or by the addition of magnesium chloride, which forms finely divided magnesium hydrate which fills the pores of the structure. The concrete may be also made waterproof by suitable agents, or by coating it with bitumen, asphalt, or tar, though such coatings are usually too costly. The second method consists in using cement which does not contain the compounds required to form the crystals, such as the substitution of cement containing iron oxide in place of the alumina in Portland cement, or in the use of slag cements low in lime; the latter is at present one of the most certain preventives. Alternatively, material may be added such as puzzolana, trass, brick dust, granulated slag, santorin, earth, etc., which can combine rapidly with the lime set free by the action of water on the Portland cement. Such materials reduce the porosity of the cement, but their chief action is in converting the lime into a compound which cannot at all take part in the formation of the double crystals. Unfortunately, the reaction between the lime in the cement and the silica in the added material is so very slow that such materials do not invariably prevent the formation of the crystals.

The Protection of Concrete Buildings Against Damp

From La Revue des Materiaux de Construction et de Travaux Publics, Paris.

General opinion to the contrary, a concrete which is impervious to water it not necessarily impervious to damp. The chief causes of humidity in buildings are: (1) Damp foundations. (2) Dampness or water gaining access to the lower part of the building other than damp in the foundations. (3) Rain water beating against the walls of the buildings. (4) Faulty or negligent construction whereby water penetrates the walls. (5) Sweating of the walls.

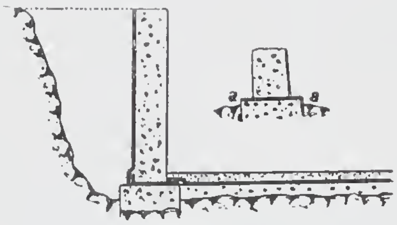


Fig. 1—Impermeable Sheeting.

The ground both inside and around the structure should be made damp-proof and all access of surface water should be cut off. The walls should be built in such a manner that rain cannot be driven into them so as to reach the inside faces. A cavity wall is often superior to a solid one in this respect.

The entrance of water through openings in the walls or at the eaves is chiefly the result of defective workmanship, but may usually be remedied by suitable treatment.

The sweating of the walls on the inside of the structure is due to sudden changes in the internal and external temperatures, whereby warm, moist air is brought into contact with the cold concrete and condensation occurs. This may be prevented by interposing a protective material whose temperature is intermediate between that of the warm air and the cold wall, or by building the walls in such a manner that the temperature of the air in internal surface has no relation to that of their outer surface. Hollow blocks are recommended.

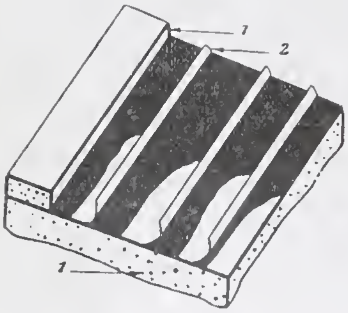


Fig. 2.

1. Concrete.
2. Layers of felt.
Black: lac or bitumen.

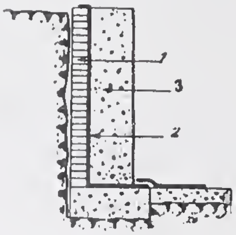


Fig. 3.

1. Wall of light bricks.
2. Impermeable sheeting.
3. Concrete foundation wall.

To prevent the unpleasant effects of dampness it is desirable to:

Apply superficial coats, such as paints, plaster or substances of a membranous nature to the damp portion.

To apply an integral method in which water or damp-proofing material is added to the concrete while the latter is being mixed and before the walls are built. The material may be added in solution or it may be mixed dry with the cement. The liquid agents are supposed to be uniformly mixed with the material, but the dry and finely powdered agent is usually the more convenient.

The possible action of the water-proofing agent on the reinforcement and on the concrete proper should also be ascertained at various temperatures so as to avoid corrosion. The following proportions are suggested where dampness or water is to be combated.

For 4 parts of crushed stones, ¼ to ½ in. diameter, a mixture of 1 part of cement and 2 parts of sand containing rather more fine grains than are needed to obtain a concrete of maximum strength.

For smaller stones (½ in. and less) a 1:1:2 mixture will give better results than a 1:2:4 concrete. Recent investigations have shown that natural gravel stone gives a more impervious concrete than one made with crushed stone.

For mortars for recovering facades a mixture of 1 part of cement to 3 parts of sand is excellent, while a 1:2 mixture is equally suitable for foundations.

Concrete is made more damp-proof by the addition of hydrated lime to each 100 lb. of cement used.

The use of coatings and plasters protects concrete against both dampness and water in large quantities and their decay is by no means rapid. They may be applied advantageously to surfaces above ground level or to the interior of tanks and other containers. They usually consist of solutions of soap and alum, coatings of tar or paraffin, cement slurry containing a waterproofing agent and applied in a series of layers.

Another group of superficial protecting agents includes elastic materials such as tar, asphalt, etc., which are applied hot, and sheets of felt. To be effective such materials must completely cover the surfaces to be protected, especially at the joints. When the pressure of a liquid is to be resisted, alternate layers of felt (either coated with tar or not) and of asphalt, or preparations with tar base, are used, the number of coats varying with local conditions, one to six coats being applied. See Figs. 1 and 2. A ¼-in. coat of mortar cement 1:2 may be applied as a finish. This method of waterproofing is preferably applied during the construction of the building.

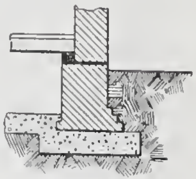


Fig. 4.

In waterproofing foundations, a bed of impervious material should be laid to form the base, on which is placed a sheet of tarred felt which goes beyond the wall on each side. When the wall is complete and the setting of the concrete is certain, the sheet is folded up against the wall and attached by means of asphalt or tar. The outer side of the wall is then tarred from above downwards, and special care is taken to make good joints. In Fig. 1 sufficient space is left on both sides of the wall to enable the workmen to move about readily and to facilitate the application of the sheets. Where there is less space the arrangement shown in Fig. 3 may be used, the work being commenced by building a wall of brickwork, lining this on the inside with impermeable sheeting and then placing the concrete close to the latter.

When there is no cellar it is desirable to place sheet lead, bitumen or other composition between the walls of the foundations and those of the building proper to act as a damp course (see Fig. 4). It is necessary to ventilate the space between the foundation and the ground floor by means of protected openings in the foundations.

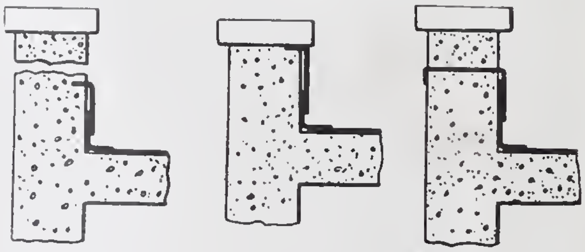


Fig. 5—Methods of Making Good Joints Between a Balcony Projecting Wall or Chimney and Roof.

The following experiment is instructive: If one edge of a sheet of blotting paper is dipped in water the latter will raise up the paper, and if the latter is in contact it will soon be saturated. If a sheet of the same paper is wet and placed in a closed vessel with another (dry) sheet of blotting paper near to but not touching it, the dry sheet will be quickly dampened by the moisture from the first sheet. If, however, a current of air is allowed to circulate freely in the vessel the wet sheet will dry rapidly without the dry sheet being affected. A similar phenomenon is observed in buildings.

Thus, if two parts of a solid wall are connected by a porous joint, any moisture in one part will be transmitted to the other through the joint. If two walls are separated by a closed space filled with stagnant air the moisture will tend to pass from one to the other, but if the cavity is properly ventilated the interior wall will remain dry. This does not mean that a system of ventilation is essential, but that the enclosed air must be sufficient to absorb and to retain all the moisture under all conditions.

When metal or other ties which are likely to be damaged by moisture are employed they should be covered with a plaster in order to preserve them.

Continuous wall-cavities are liable, in case of fire, to prove very dangerous, as they act as flues and increase the distance traveled by the flames. For this reason and because they are primarily used to prevent damp interiors such cavities should be broken into smaller ones, not open to the atmosphere.

When concrete paints are used as waterproofing agents it is imperative that the concrete should be quite dry. The various preparations of this character each have their special advantages—some preserve the outer surfaces of the concrete or prevent efflorescence. Others preserve the interior surfaces of the building. In either case all cracks should be filled before the paint is applied.

A roof is waterproofed in the same manner as any other part of a building. If it is of concrete a good waterproofing agent such as tar, felt and asphalt, may be applied to either the apex or lower surface. The joints between the wall and certain other parts of the building such as chimney, skylights, etc., or between the latter and the roof should be made with special care. Figure 5 shows three methods of making a good joint between a balcony projecting wall or chimney and the roof.

If dampness penetrates through the space between window or door frames and the walls, attention should be paid to such spaces, and if one of the applications previously mentioned is made with sufficient care it will usually prevent any further trouble.

Reinforced Concrete Caissons for Bridge in Italy

The bridge constructed over the Crate connecting the residential part of Rose with the Libari-Cozeza Ry. and the National Calabrian Ry. is 1,170 ft. in length and 40 ft. in width. It is divided into four parts and is calculated to carry a load of 130 lb. per sq. in. The most interesting feature of the bridge, according to Annali d'ingegneria e d'Architettura, is the caissons of reinforced concrete which are in the form of an inverted rectangular tank with sloping interior sides and vertical exterior ones, the reinforcement being of three kinds: (a) stout bars conforming to the interior of the caisson; (b) lighter rods placed near the exterior, and (c) still lighter ties uniting the other reinforcement.

The greater part of the concrete consists of a mixture of Portland cement, sand and gravel in the proportions 2:3:6, but the exterior was finished with a grouting composed of one ton of Portland cement to 1,000 cu. yd. of fine washed sand.

Use of Fuel Oil in France.—A commission appointed by the French Minister for Public Works to study the question of oil fuel in France has recommended the substitution of heavy oil fuel for coal everywhere in the heavy industries and all public services as a matter of the greatest possible urgency. A progressive program is to be worked out for the adaptation of boilers and plants to burn oil fuel. An organization is to be set up for at least five years for the national supply of heavy oil fuels in coordination with the scheme for importing and producing coal. The commissariat-General estimates that the monthly requirements of fuel oil will be about 100,000 tons. The cost of a ton of American oil fuel is about 270 francs, as against American coal at 280 francs. To allow for a small profit for importers the price for the best quality of fuel oil has been fixed at 300 francs the ton.

British Trade Unions and Unauthorized Strikes.—Seven of the largest trade unions in Great Britain have inaugurated a movement aiming at the prevention of unauthorized strikes. It is said the movement is sponsored by the National Union of General Workers.

Effect of Road Conditions on Motor Truck Operation

By W. D. WILLIAMSON

Abstract of a paper presented Nov. 25 at the Road and Transport Congress of the County Councils' Association

From the point of view of national interest, the preservation of vehicles is just as important as the preservation of roads, and it is just as necessary to pass regulations governing the strength and the nature of the surface of our roads as to pass regulations controlling the weight and speed of the vehicles using them.

The unfortunate position is that road makers are not direct profit earners. The commercial-vehicle manufacturer who builds a better vehicle obtains more orders, and other things being equal, achieves greater business success. The user who purchases the best vehicle, and who organizes his transport arrangements to give the best service also builds up a successful business. In the case of the road engineers there is no such inducement. At present it might be argued that the reverse is the case. The better the roads, the more traffic is attracted over them, and the more wear they have to sustain.

On the present roads, which in many cases are just good enough to carry the traffic, high speed would undoubtedly be destructive to the road, and at the same time would be equally destructive to the mechanism of the vehicle. No motor manufacturer would suggest driving a vehicle over any road at a speed that would abnormally reduce the vehicle's life. Given suitable roads, however, the speed of heavy trucks would be very materially increased. The user of the truck naturally wishes to make the most of its possibilities, and he is the man who is most immediately concerned in getting higher speed and increased efficiency from his vehicles. The manufacturer is interested in it from the fact that anything which increases the efficiency of the vehicle increases the uses to which the vehicle can be applied and, therefore, the demand for vehicles.

The service capacity of the trucks we own in this country is reduced by between 25 per cent and 50 per cent due to restricted speed alone. The writer does not mean to infer that this is necessarily the case with our present roads, but given roads equal to our best roads, that would stand the traffic, there is no reason, either from the motor manufacturers' or the users' points of view, to prevent an increased speed, and consequently much more service from any given number of vehicles.

When considering the running cost of tires, it should be pointed out that the interests of the road maker and the road user are here identical. One cannot have tire wear without road wear. The interests of the user are naturally to obtain the longest possible life from his tires, and the interest of the road maker to obtain the longest life from his road. The designer and manufacturer of the vehicle, in thinking in terms of total cost of operation, must take the question of tire wear into account, and incidentally, therefore, road wear.

Tire wear is caused very largely by wheel spin on rough road surfaces. When the wheel rises from the road, after striking an obstacle, its speed of rotation immediately increases, and by the time it hits the ground again the surface of the tire is traveling at a speed too high for the speed of the truck. This is one great cause of tire abrasion, and must equally cause road wear. The effect of the roads on tires is well illustrated by the mileage obtained from tires used on buses in the London streets, compared with mileage that could be obtained on vehicles in Lancashire. In pre-war days 15,000 miles to 20,000 miles could be obtained from a set of tires in London, whilst on the rough roads in Lancashire tires in many cases failed to give the guaranteed mileage of 10,000.

Practically all petrol-driven commercial vehicles used in this country having a carrying capacity of over 1 ton are shod with solid rubber tires, but this is not by any means the last stage of development. Trials are being made, both in France and in America, of pneumatic tires for heavy vehicle use, and improved road surfaces would undoubtedly hasten the advent of this very desirable development.

Monsieur André Michelin has conducted a large number of experiments, during the last two and a half years, in the use of multiple pneumatic tires for heavy vehicles. The result of the tests, as far as the tires alone are concerned, has been very satisfactory. The chief difficulty appears to be of a mechanical nature, connected with the production of a satisfactory detachable rim, to allow for the handling of large-size pneumatic tires.

To examine in detail the effect of the roads on the running cost of a vehicle the following figures are put forward, not necessarily as being strictly accurate, since costs must vary from district to district, but as being approximate for average conditions. The vehicle under consideration is one for useful loads of 4 tons, the vehicle itself weighing 4 tons, making a gross weight of 8 tons distributed as to 2 tons on the front axle and 6 tons on the rear.

Present legal speed of vehicle, 12 m.p.h.
Cost of vehicle, about £1,200.
Tires, per set, about £60.
Weekly mileage, 300 for 50 weeks a year.
Interest is charged on the total price of the vehicle.
Depreciation is charged on total cost less the cost of tires, which are accounted for as a separate item.
Petrol consumption, 7 miles per gallon.

RUNNING COST OF 4-TONNER AT PRESENT.

	Yearly cost.
Interest at 5 per cent	£ 60
Depreciation at 15 per cent	170
Driver's wages, 65s per week	169
Insurance	15
Petrol at 2s 8d per gallon	286
Oil and grease	25
Tires (life, 10,000 miles)	90
Repairs	100
Total yearly cost	£915
	d.
Cost per mile	14.64
Useful load cost per ton-mile	3.66

If roads were uniformly good the useful load could be increased by at least half a ton for the same gross weight of vehicle. The speed of the vehicle might quite safely be increased to 16 m.p.h. The tire life could at a very low estimate be taken at 50 per cent more. Taking the average tractive resistance of our present roads at 60 lb. per ton, and of the good road at 30 lb. per ton, in spite of the extra speed we should have a reduced petrol consumption, and this is taken at 9 miles per gallon. The repair bill would certainly not be more, and depreciation would be materially less.

The running cost would then be as follows, taking a yearly mileage of 18,000:

	Yearly cost.	
	£	s.
Interest at 5 per cent	60	0
Depreciation at 12½ per cent	142	10
Driver's wages	169	0
Insurance	15	0
Petrol at 2s. 8d. per gallon	267	0
Oil and grease	30	0
Tires (life, 15,000 miles)	72	0
Repairs	100	0
Total yearly cost	855	10
	d.	
Cost per mile	11.4	
Useful load cost per ton-mile	2.53	

This shows a saving of over 30 per cent on our total haulage costs, and is a result worth more than mere monetary consideration.

The present 5-ton vehicles would safely carry an additional ton of useful load on really good roads, and the legal speed, instead of 8 m.p.h., could be at least 12 m.p.h. This would show an even greater percentage of saving than the 4-tonner.

To conform with the present maximum axle weight of 8 tons for heavy vehicles, the ordinary petrol truck can carry little more than 6 tons. An increase in the permitted axle weight, in conjunction with suitable roads, would reduce the cost of transport enormously. The cost per ton-mile of useful load decreases with an increase in the load.

In addition to making allowances for the actual surface, the automobile engineer has to design a vehicle to negotiate deviations from the straight line in both horizontal and vertical directions. In order to be able to steer a long vehicle around a short radius the wheel base must be reduced with the effect, as seen in many char-a-bancs, of having excessive overhang. These sharp corners also make for rolling and are the cause of additional tire wear.

Deviations from the straight line in a vertical direction are generally the result of the physical characteristics of the district through which the road is made, but careful engineering can lay a road having reasonable gradients through the most unpromising country.

If we compare the gradients on a well-laid road with those of the railway we see how far from ideal is the road. In order to be able to climb gradients on the present roads vehicles have to be fitted with engines considerably bigger than would otherwise be necessary. This means, that practically the whole time the engine is working at about half full load, and consequently is not working economically.

There are also smaller artificial rises, such as one finds on secondary roads, in particular over small bridges which, if crossed at a high speed may be the cause of serious damage. A sudden change of gradient, as on a humpy bridge, means the necessity for high clearance amidships of a car or truck.

Considerations of gradient and road surface play a very important part in the question of weight distribution. Take as an instance the case of a vehicle which, in its daily work, has to climb a hill having a soft and slimy surface; instead of the coefficiency of friction between the wheel and the road being in the neighborhood of 0.4 it may diminish to 0.2, and yet the tractive resistance of such a surface might be 100 lb. per ton. Taking the vehicle as weighing 8 tons gross, and the gradient as 10 per cent, we have:

	Lb.
Tractive resistance due to gradient	1,792
Tractive resistance due to surface	800
Total tractive resistance	2,592

This means $2{,}592 \div 2 = 12{,}960$ lb. weight on driving wheels to give the required grip.

Therefore, at least 5½ tons of the total weight of the vehicle must be on the driving wheels to meet these conditions, whereas with a coefficient of friction of 0.4 half this weight would have been enough. The retarding power of the brakes is subject to the same influence.

The road of the future should be constructed entirely from considerations of its suitability for self-propelled vehicles. In the future the horse-drawn vehicle will as rarely be seen as is the bullock wagon.

The first great necessity is a series of wide trunk roads constructed specially for motor traffic. Roads with good foundations and waterproof surfaces which will not wear into pot-holes. These main trunk roads should not, as a general rule, pass through large towns, but should pass on the outskirts, and be linked up with the towns by equally good, but not necessarily such wide roads. The through traffic would not then have the effect of further congesting local traffic, and the local traffic would not retard fast through traffic. In the event of works, warehouses or other business premises being built near these roads, care should be taken that the free passage of moving vehicles is not prevented by vehicles delivering or receiving goods.

The automobile engineer would like to see all roads on much more substantial foundations than are usually used, in order to carry greater weights at higher speeds, and having an upper wearing surface of a dustless character which can be easily renewed. It ought not to be impossible to build such roads and allow on them an axle weight of, say, 10 tons with a gross weight of 15 tons and a speed of 16 m.p.h., for vehicles fitted with rubber tires of agreed dimensions, even if the increased speed is not at once permitted on existing roads of a less substantial character. Further, when any vehicle is using the roads strictly in accordance with the regulations, it should not be possible for the vehicle to do "extraordinary damage."

Corners should be eased and blind corners entirely eliminated. At all corners the road should be given super-elevation. This is already being successfully done by some engineers. The super-elevation eases the vehicle round the corner, prevents tire slip, and consequently prevents wear on both tires and road. The foundations of the road appear to be much more important than the top surface. It ought not to be permissible to put pipes, drains, electric cables or anything else beneath the roadway which may make it necessary to excavate. The foundations of a road should be solid and permanent.

To prevent accidents reasonably open spaces to cross roads are required. Reconsideration of the camber of roads is necessary; roads with a dressed surface such as tar macadam roads, which are waterproof from their construction, do not require the camber often found in roads today. The road surface should be of such a nature as to have low resistance to rolling, while the coefficiency of friction between the road and the wheel should be high.

The present methods of indicating direction in many cases leave much to be desired; improvements could be made at very little cost.

British Portable Military Bridges

By PROFESSOR C. E. INGLIS,

From The Engineer, London, Sept. 26, 1919.

This paper deals mainly with the evolution of a type of military bridge which on account of its portability and ease of construction became in the later stages of the war the standard type for rapid advance work, capable in its various forms of carrying light and heavy military transport across clear spans up to 100 ft., and sometimes even more.

The light-type bridge consists, as shown in Fig. 1, of a number of four-sided pyramids. Their bases joined together form the roadway, and a series of struts coupling together the apexes of successive pyramids constitute the top compression boom of the bridge. The main members are steel tubes attached at their ends to cast steel junction boxes. The bays of which the bridge is formed are all identical, each consisting of the following parts: Two horizontal tension tubes, one horizontal compression tube, one cross beam or transom, one pyramid, and one gangboard. The four legs of the pyramid are permanently hinged to the top junction box, and fold together to form a single unit convenient for transport. The square base to which the lower ends of the pyramid legs are attached is braced by diagonal rods, which can be strained tight by means of turnbuckles. These diagonal bracing rods are permanently hinged to the transom and form an integral part of that unit.

The roadway in its earliest and simplest form consisted of a single central line of gangboards with their ends resting freely on the transoms, and of just sufficient width to allow the passage of infantry marching in single file. Later on a more commodious decking was provided, which enabled horses to be led across the bridge. The base of the pyramid is an 8-ft. square, and the vertical height of the compression tube above the tension tubes is also 8 ft. The strength of the bridge is calculated to carry infantry in single file crowded closely together over a clear span of 96 ft. Owing to the fact that the stresses in the tubes are strictly axial, the rigidity is quite remarkable for so light a structure. The maximum deflection for a span of 96 ft. fully loaded does not exceed 2 in., and the triangular section of the girder renders it almost equally stiff in a lateral direction. The weight of a bay, including the footway, is 510 lb., so that the weight of a 96-ft. span is about 2¾ tons. These weights and dimensions do not refer to the first experimental bridge made at Cambridge, which was a more fragile and less commodious construction.

If inverted, the construction becomes a deck bridge suitable for a class of light wheeled traffic which could not pass through the triangular gage of the bridge in the normal position. When used upside down the bridge is supported on substantial projecting horns, which are bolted to the two end transome. In this form the bridge also provides a convenient arrangement of false work for the erection and launching of heavy girders across a gap.

Method of Launching Bridge.—The bridge, with an extra length of tail to serve as a counterweight, having been assembled, an additional counterweight generally in the form of a human load is added to the end bay of the tail until the whole construction see-saws about the axle of the trolley. The complete structure is then swung around, the two independent wheels of the trolley acting as do the rollers of a turn-table. When the outer end reaches the opposite bank, the counter-balance tail is dismantled and the trolley removed. The decking having been placed in position previously to the process of swinging, the bridge is then ready for traffic. It may happen that the configuration of the banks or the presence of obstacles such as trees and telegraph poles precludes the possibility of swinging. In this case there remains the alternative of building the bridge at right angles to the banks of the gap and pushing it bodily forward on its trolley like a ship's gangway. With a bridge arm of 104 ft. extending out as a cantilever from the trolley, the tube stresses are considerable, and the factor of safety is less in this condition than when the bridge is in position fully loaded. Moreover, the bottom horizontal tubes, which are normally in tension, have during this stage to act as compression members, and this consideration is the main factor which governs the design of these so-called tension tubes.

Bridge for Motor Trucks and Heavy Guns.—After the trial of the light bridge, which took place in December, 1915, evolution was rapid. Branches of the service other than the infantry immediately claimed consideration, and to meet the demands of the gunners and the Army Service Corps in particular an enlarged type was produced. The bays in this case were 12 ft. wide and 12 ft. long, and the pyramids were 12 ft. high. In this form the bridge could carry field guns and general service wagons crowded as close as possible on a 96 ft. clear span, the safe distributed dead load for this span being 24 tons. With the exception of the decking it was practically a copy of its predecessor, the light-type bridge. The decking consisted of two longitudinal lines of gangboards flanked by rolled steel joists laid on their sides. The joists formed strong troughs in which the wheels of the vehicles could run, an arrangement made possible by the fortunate circumstance that the various vehicles which had to be catered for were almost identical in the matter of their wheel tracks.

Before this 12 ft. type had come forward in any quantity, the question of a rapid bridge for motor lorries and heavy guns was raised, and this demand was in the first instance met by a twin bridge construction. In this design a central roadway 10 ft. wide between kerbs is supported on substantial trussed beams hung from the centers of the transoms of the two parallel bridges; wheeled traffic passes along the central roadway, and the supporting bridges form side tracks for pedestrians. A similar twin construction, adopted in connection with the light bridging material, found favor with the cavalry, and survived without further modification to the end of the war. The large twin bridge, on the other hand, was soon superseded. Its chief advantage lay in the fact that it utilized existing material, but it possessed the serious drawback of beating uncomfortably wide compared with most road bridge abutments, and the large number of different parts required for its construction was also a disadvantage.

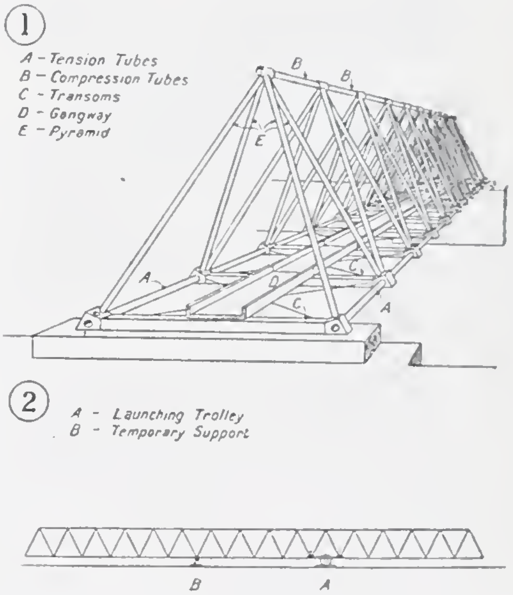


Fig. 1—Tubular Infantry Bridge.

Rapidly erected bridges for motor lorries were without doubt by that time urgently required, and the great development and extreme importance of this class of traffic appeared amply to justify a special design. The design of this motor lorry bridge differs in one important respect from that of its predecessors in that to obtain a sufficiently commodious traffic gage the pyramid form of construction is abandoned. In the design of the main joints and in the method of launching the system remained unchanged. This type of bridge was used extensively during the last rapid advance stage of the war.

Main Joint of the Tubular Bridges.—The main joint is represented in Fig. 2, and was common to all the tubular bridges, both light and heavy. A is the junction box made of cast steel. B is a steel tongue permanently screwed into the thickened end of a tube member, and C is a nut which turns freely on a fine thread—11 threads to the inch—cut on the tube. To make the connection the nut is run back on its screw two or three turns and the tongue inserted into the junction box. The pin D is then passed through the slot in the tongue and through the two corresponding slots in the sides of the junction box. The semi-circular ends of the slots are machined to fit the pin; in other positions the clearance between the pin and the sides of the slots is at least ⅛ in., so that there may be no difficulty in inserting the pin if the nut is slacked back sufficiently. At this stage the connection is in the nature of a pin joint with ⅛ in. or so backlash. This blacklash is then taken up by screwing the nut into contact with the machined boss at the end of the junction box. Continuing to screw, the tongue tends to draw out of the junction box until further movement is resisted by the pin bedding itself firmly between the three bearing areas. The connection thus tightened up is in effect a stiffened pin joint, and the ends of the tubes are rigidly constrained in direction—a circumstance which adds materially to their power of resistance when acting as struts. In the case of compression members the load is all transmitted through the nut, and in the case of tension members the pull is resisted by the pin. This type of joint is peculiarly fool-proof and dirt-proof. The screw thread outside the tube is always protected by the nut, and the positions of the bearing surfaces inside the slots render them almost perfectly immune from accidental damage.

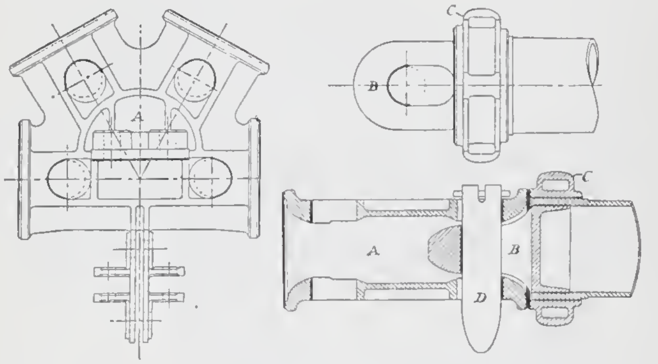


Fig. 2—Main Joint Assembly.

Method of Connecting Tube Ends.—Perhaps the most difficult problem encountered in the whole design of the bridge was the determination of a thoroughly satisfactory method of connecting the tube ends permanently into the tubes. The ideal aimed at was to obtain an attachment possessing an efficiency of over 100 per cent, or, in other words, an attachment which would break the tube rather than let go. In the very first light bridge in which the tubes were of comparatively thin gage, a fairly satisfactory connection was made by rolling the tube into corrugated grooves turned in the cylindrical portion of the tube ends. For thicker tubes it was found that in forcing the tube well down into the grooves the walls of the tube in the region of the grooves became appreciably reduced in thickness, and the strength of the tube suffered in consequence. The oxy-acetylene welded connection was then tried. Samples of this attachment under test gave excellent results, and this type of connection was adopted in the construction of the second experimental light-type bridge. This connection was never quite up to the full strength of the tube, but it did not fall far short of it, and was quite capable of stressing the tubes well beyond their elastic limit. However, after a brief reign, this method of attachment was abandoned owing to the human element making itself apparent as soon as production on a large scale was called for. If carried out by really skilled and experienced workmen, the results were satisfactory, but there was no room for faulty work, and, unfortunately, it is quite impossible to detect a faulty weld by a mere superficial examination. Each attachment had to be tested separately under tension, and the number of failures under test was so serious that this type of connection was hastily abandoned.

The method of attachment which was finally and satisfactorily adopted is shown in Fig. 2. The tube end in this design is screwed into the tube, which is thickened at its extremities to compensate fully for the loss of section due to the cutting of the inner and outer screw threads. The attachments at the opposite ends of the tubes are screwed right and left-handed respectively, and in this way the distance between the pin centers of the two end tongues can be adjusted to any desired degree of accuracy. The nut enclosing the end of the tube effectively eliminates all possibility of the attachment escaping by bursting the end of the tube. This type of connection gave entire satisfaction, and, although the practice was continued of testing all tubes in their finished state nearly up to their elastic limit, this test was continued more with the object of eliminating the remote possibility of a burnt tube than in the expectation of a faulty attachment, which never from the first gave any cause for anxiety. The tubes were of the lap-welded variety. In order to ensure a good weld which would stand up under the drastic process of staving the ends, the steel employed was of a soft, mild description having an ultimate tensile stress of about 28 tons per square inch and an elastic limit which was usually about 14 tons per square inch, though not more than 12 tons was guaranteed by the makers.

Loads and Decking for Rectangular Bridges.—Profiting from previous experience, the rectangular bridge for motor truck traffic was made considerably stronger than the needs of the moment dictated, being designed to carry a dead load of 84 tons distributed over an 84-ft. span. Under a test load of 100 tons of pig iron the central deflection produced was 1⅓ in., which was entirely recovered on removing the load and proving thereby a complete absence of overstrain. Under the designed load of 84 tons the maximum tube stress was limited to 7½ tons, or about half the elastic limit of the tubes. The external diameter of the tubes was arranged so that the compression tubes were not loaded up to more than one-third of their theoretical buckling load. These two conditions definitely prescribed the outside diameter and the thickness of the tube, which for the horizontal members were 5¾ in. and ⅜ in. respectively, and for the diagonal tubes 5¾ in. and ¼ in. Each bay in skeleton weighs about 1¾ tons, and, complete with decking, a 96 ft. span of eight bays weighs 25½ tons, which compares very favorably with any other type of military bridge having approximately the same carrying capacity.

As regards the decking, the road bearers, seven in number per bay, are 8 in. by 4 in. steel joists running longitudinally with their ends resting freely on the transoms which are provided with cleats to preserve the correct spacing of the bearers. The two outside joists are fitted with cast steel buttons pitched 9 in. apart center to center, and into the intervening spaces 8 in. by 4 in. pitch pine transverse deck planks are laid. This planking is held down by kerbs and hook bolts, and the decking is completed by the addition of side screens. The traffic gage is a rectangle 12 ft. 6 in. high by 11 ft. 6 in. wide, and the width between the kerbs is 9 ft. 4 in. To effect the erection of the upper tubes, transverse stiffeners and bracing, a movable staging of step ladders and horizontal platforms extending over a length of two bays is provided.

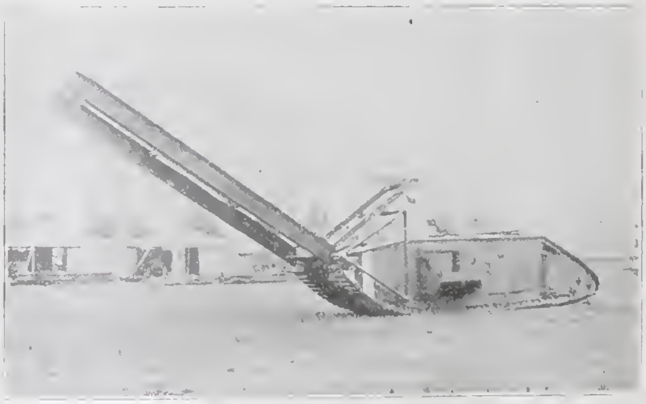


Fig. 3—Tank Carrying 25-ft. Span Bridge.

Trolley for Launching Bridge.—As in the case of its predecessors, the bridge was constructed on a two-wheeled trolley. A noticeable feature in the design of this trolley are the four lifting screws by which the bridge is suspended from the trolley. When the bridge has been swung across the gap it is readily lowered down on to its abutments by means of these screws and the trolley can then without difficulty be detached and rolled out of the way. The lowering screws are doubly articulated at each end, which gives them perfect freedom to take any oblique direction arising from a tilt either of the trolley or the bridge. The wheels are steel castings with cambered treads to facilitate the process of swinging. It is essential in most cases to provide a rigid platform for the trolley, and a double layer of the deck planks serves very well for this purpose. On a surface of this sort a couple of men can readily rotate a length of 180 ft. of bridge.

Under favorable conditions such as exist at a bridging school, and with 80 trained men, a 96-ft. span bridge of this type can be completed in about four hours. Under service conditions and working in the dark, as was the general practice, the time occupied was usually about eight hours, or, at any rate, sufficiently short to enable the construction to be completed in the course of a single night, and thereby escape enemy observation, which rendered bridge-building in the daytime well-nigh impossible.

Bridges to Carry Tanks.—We now come to the last phase in the evolution of these bridges. After the great military value of the tanks had become an established fact, the Tank Corps recognized that in order to develop this new weapon of offense to its fullest possible extent, it must possess a large number of fighting bridges specially designed to meet its own requirements, capable of very rapid construction, and able to force the passage of a river even in the face of a determined enemy. For spans in excess of 25 ft. the tubular form of construction was selected. The 12 ft. rectangular type, though strong enough in its tubes to carry a 40-ton tank across an 84-ft. gap, was deficient in strength in its transoms and decking, and, furthermore, its width was insufficient to accommodate the largest male tanks with their widely projecting sponsons. Accordingly, a new design was evolved.

This bridge was 40 per cent heavier than the 12 ft. type, but as a compensation for the extra weight the time of erection was reduced by at least a half. The bays of this enlarged bridge are 15 ft. long and 15 ft. wide. The horizontal tubes are identical and interchangeable with the diagonal tubes, so that in side elevation the panels are approximately equilateral triangles having a height of 13 ft. This obvious simplification was not possible in the case of the 12-ft. type, since the height of a 12-ft. equilateral triangle did not give the head room necessary for motor lorries. In most other respects, however, the new bridge was merely an enlarged edition of the 12-ft. design. The tubes have an external diameter of 6¾ in., with a thickness of ⅜ in., and each tube complete with its end attachments weighs 4 cwt.

The narrow track of the tanks concentrated the load on the transoms to such an extent that nothing less than an 18-in. by 7-in. steel joist would suffice. The decking is supported on four 12-in. by 6-in. steel joists, and the deck planks are 10-in. by 5-in. pitch pine. Light footways on either side of the 10-ft. main roadway are an additional feature of this bridge. The weight of a bay complete with its decking is 6 tons, of which 3 tons is due to the road bearers and deck planking. The bridge was primarily designed to take a 40-ton tank over a clear gap of 90 ft., but the span can be increased to 105 ft. without incurring serious stresses. In this connection it should be noted that the progression of a tank is so smooth that practically no allowance for impact need be made, whereas in the case of motor lorry traffic an impact factor of 2 was used in stress calculations.

Erection by Light Tubular Derricks.—The reduction in time of erection was brought about by the utilization of light tubular derricks in palce of the comparatively clumsy timber staging employed previously in the process of construction. The attachment of the tubes to the transverse stiffener was done at ground level, and a unit consisting of this stiffener with four tubes attached was hoisted up in one piece by the derricks, only two men being required up aloft to couple this unit up to the existing part of the structure. By this simple device the time occupied in the erection of a bay was reduced by one-half, and, including the shifting of the derricks, it has been found possible for erection to proceed at the rate of a bay in 10 minutes. Assuming that this rate of progress is maintained, two detachments working simultaneously at the two ends of the bridge will construct twelve bays, or 180 ft. of bridge, in an hour; but, to allow for accidental delays, such as the jambing of a pulley block chain, at least 50 per cent should be added to this time.

Combined Tubular and Pontoon Bridges.—With a bridge built and launched in the ordinary way 105 ft. marks the limit of clear span which can be used with safety for the transportation of 40-ton tanks. Tanks, in advancing, had, of course, to contemplate crossing rivers of far greater width, and for this purpose a combined tubular and pontoon bridge was designed. In the design adopted, as worked out for a bridge length of 240 ft., the middle portion of 120 ft. has a pontoon under each transom. This portion is in effect, a boat 120 ft. long with such ample fore and aft rigidity that a tank coming on at one end merely alters the fore and aft trim of the structure and does not call upon any one pontoon to carry the whole concentrated load of the tank. Clear approach spans of 60 ft. are provided at each end, and the articulated joints come in most conveniently for connecting these approaches to the floating portion. If articulated joints are introduced every 180 ft. or so, this type of stiffened pontoon bridge admits of indefinite extension, and the construction can be proceeded with as rapidly on water as on land, pontoons with transoms on board being floated up in turn to the head of the bridge and linked up there by means of the tubular construction.

Bridge for Crossing Canals.—The last bridge is lowered until the head of the bridge takes the ground on the opposite bank. The supporting slings, being relieved of tension, then automatically let go, and a further slackening of the tackle lowers the heel of the bridge on to the ground. Backing away slightly, the tank detaches itself from the forked end of the bridge, and it is then free to proceed across the bridge, the derrick and triangular frames remaining, of course, attached to the tank. Guided by strong channel irons the tank crosses upon the flanges of the girders without any intervening timber decking, which can be added subsequently and in safety after the tank advance has effectively dissipated the enemy opposition.

Design of Wooden Roofed Structures in Accordance With Actual Loading

By LT. COL. H. L. LEWIS,

From The Royal Engineers' Journal, London, November, 1919

Even before the war it occurred to many officers that recognized methods of designing roofs gave results that erred very much on the side of safety, not to say extravagance. During the war, and especially in its later stages, the shortage of material enforced a reduction in the size of members, and it was found that roof structures cut down to a fraction of the strength that would have been considered normal in peace time, were able to fulfil their purpose, and, in exposed situations, to survive repeated storms. It became evident that the theory of roof construction required investigation and drastic revision to bring it into line with the experience recently gained.

Essentially, a roof consists of a "covering" and of a structure whose function it is to maintain that covering in place under all conditions except the most abnormal. It is now suggested that past practice resulted in some, if not all, of these members being made very considerably stronger than safety demanded. That the pure theory of roof design was at fault, may be ruled out at once, for this theory is the same as is applied to other engineering structures, and is based on very numerous experiments.

We may attribute any errors that may have arisen to one of two causes:

(1) A faulty arrangement of the members.

(2) An excessive estimate of the load that might be imposed.

As regards the first of these, it must be admitted that a very large number of roof structures are imperfect. The spacing of the trusses, the number of the points at which the principal rafters are supported by struts, the spacing of rafters, are considerations which all have their effect on the economy of design, and in the aggregate may easily make a difference in cost of 10 or 15 per cent.

Such questions rarely receive sufficient attention. Joints are often designed so as to bring about large and avoidable secondary stresses, and to meet these members must be made heavier than would otherwise be necessary. These secondary stresses are never calculated, or directly provided for, but as a sufficient factor of safety must be obtained theory is made to square with practice by allowing for a roof load greatly in excess of whatever actually occurs.

Let us consider how the roof load is estimated and whether the customary allowances are in fact justified. The permanent loads allowed for are actual existing loads, and it is only a question of estimating or measuring them correctly. This can always be done with sufficient accuracy, if not a the first, then at the second or third attempts. There remain to be considered the allowances which should be made for the various temporary loads which may be imposed, whether due to the weight of workmen, weight of snow, or to wind pressure.

Firstly as regards weight of workmen.

A very usual allowance in this case is 25 lb. per square foot, which is considered applied to battens, to common rafters, to purlins, and to trusses. In order to appreciate what this means, let us apply this allowance to a roof with a clear span of 40 ft., with trusses 10 ft. apart. The length of principal rafters will be about 24 ft., and we may assume that the purlins are spaced 6 ft. apart. Assume that the common rafters are 2 ft. apart, center to center, and that battens are spaced at 1 ft.

A load of 25 lb. dead load per foot super means on each common rafter, a dead load of 300 lb.; on each purlin, a dead load of 1,500 lb.; on each truss, a dead load of 12,000 lb. So that, so far as workmen are concerned, the assumed load is equivalent to about:

1¾	workmen on each common rafter.
9	workmen on each purlin,
70	workmen on each truss,

taking the weight of one workman at about 170 lb.

Stated in this way, it is evident that, whereas 25 lb. per square foot is not an unreasonable allowance for workmen in considering the load that may come on a common rafter, it is a wholly absurd allowance as applied to a purlin or to a truss.

A common rafter may have to bear the bulk of the weight of a single workman, being live load and not too well distributed. A purlin is most unlikely to have to bear more than four workmen at one time, at the very outside, or a total load of 680 lb.

If any of the overlaying structure is in place, this load will be fairly well distributed, and as the men will have to move cautiously it may be considered a very nearly dead load. If, on the other hand, the superstructure has not been placed, the load is less well distributed and is more suddenly applied, but on the other hand, the permanent load is absent.

We may assume here that, for four workmen, a total load allowance of 680 lb. or at the rate of 11½ lb. per square foot is well up to the mark.

Were the purlins spaced closer together, there would be proportionately fewer workmen on each, and the same allowance, say 12 lb. a foot super would be ample.

The truss will never have to support 70 workmen at one time. We may put the maximum number conceivable for a roof of this span at 10 on each side, which works out to an allowance of 7¼ lb. per square foot of roof slope. Such loads can always be considered dead and distributed.

It should be noted with regard to rafters, purlins, and trusses that a factor of safety will be applied to both permanent and temporary loads and that the former being invariable, the actual margin available to meet unusual variations of the latter is greater than is apparent at first sight.

It would appear therefore, that for the roof which is being considered, and for all similar roofs, the following would be a fair and sufficient allowance for workmen, provided the ordinary rules for good construction are followed:

	Per sq. ft.	
On battens and common rafters	25	lb. per foot super.
On purlins	12	lb. per foot super.
On trusses	7½	lb. per foot super.

Allowance for Snow.—In England, it is rare for any considerable quantity of snow to lodge on a sloping roof. If the slope of the roof exceeds 45°, no allowance need be made. On flatter roofs, and in the absence of strong wind, a considerable thickness of snow may collect and may remain for several days.

The average weight of fresh snow is about 8 lb. a cubic foot, and on a roof of very flat pitch this might accumulate to a depth of 2 or even 3 ft. On the average slate or tiled roof a depth of 1 ft. is about the maximum, and an allowance of 8 lb. per square foot is sufficient. This allowance applies equally to battens, rafters, purlins and trusses.

Allowance for Wind Pressure.—The pressure which can be exerted by wind has given rise to much discussion in the past, and fantastic allowances, some even as high as 56 lb. to the square foot, have been applied to structures.

Over a period of seven years, the highest wind pressures recorded at the Firth of Forth bridge, on two surfaces, one of 1½ sq. ft., the other of 300 sq. ft., were 41 lb. a square foot and 27 lb. a square foot respectively. The surfaces experimented on were placed high above the ground, in most exposed situations, and the locality is liable to very severe gales.

More recent experiments give results which agree closely with one another and which are expressed by the formula:

$$P = .0032 \times V^2, \text{ when}$$

P is the pressure in pounds per square foot,
V is the velocity in miles per hour.

What in Beaumont's scale is known as a "fresh gale" corresponds to a wind velocity of 48 miles per hour, whilst a "full gale" has a velocity of 67 miles per hour.

These would exert a pressure on a surface normal to the direction to the wind of 7.36 lb. a square foot and 14.4 lb. a square foot respectively, whilst a hurricane of 100 miles an hour would exert a pressure of 32 lb. a square foot.

Now in England, buildings are rarely placed in very exposed sites; the force of the wind is much broken by the unevenness of the ground, by trees, and by the proximity of other houses. In very exposed sites, special allowances should be made, but there is no reason why these allowances should be also applied to buildings in ordinary situations.

For a moderately exposed site it is suggested that a wind velocity of 48 miles an hour, with a pressure of 7½ lb. a square foot, and for an exposed site a velocity of 60 miles an hour, with a corresponding pressure of 11½ lb. a square foot will be enough.

For a tall chimney, or other high and isolated structures, a velocity of 80 miles an hour, and a wind pressure of 20½ lb. a square foot might be provided for.

All of the foregoing pressures refer to a surface normal to the wind.

For a roof sloping at 1 in 2, the pressure would be .7 of the above, and for a roof of 1 in 1, .95 of the above. For the ordinary pitch of 4 in 7, we may assume that the actual pressure, in an exposed site will not exceed .87 × 11½ lb. or 10 lb. a square foot.

Summing the foregoing results, and remembering that with a strong wind, there can be neither snow nor workmen on the roof; and that when there is snow, at most one or two workmen will get on the roof to clear it, and that they will not proceed beyond the eaves until they have cleared as far as they can reach, we arrive in the last column at the maximum allowances that appear necessary.

Member.	Weight of Workmen.	Snow.	Wind pressure.	Maximum temporary. load.
Battens and common rafters	25	8	10	25
Purlins	12	8	10	12
Trusses	7½	8	10	10

In the case of an ordinary site, not exposed to the full force of the wind, the allowance for a truss might be further reduced to 8 lbs.

Our load for purposes of calculation, in the case of a roof consisting of slates resting on battens, will then work out as under:

	Per sq. ft.
For Battens and Rafters—	
Weight of slates	6 lb.
Weight of battens	1 lb.
Weight of C rafters	1 lb.
Occasional load	25 lb.
Total	33 lb.
For Purlins—	
Weight of slates, battens and common rafters	8 lb
Weight of purlin	1 lb.
Occasional load	12 lb.
Total	21 lb.
For Trusses—	
Weight of slates, battens, common rafters and purlins	9 lb.
Weight of truss	6 lb.
Occasional load	10 lb
Total	25 lb.

As the strength of a roof is the strength of its weakest part, it is believed that a roof design based on the foregoing allowances will be no less safe than if the under portion of the structure were calculated with a higher load allowance, or what comes to the same thing, with a higher factor of safety. That such structures can be reduced much below their ordinary strength without undue risk has been proved during the war. The present cost and shortage of materials make it necessary that every possible economy should be effected, and it appears well worth considering whether some considerable economy may not be effected by adopting the system that has been explained at some length in the foregoing pages.

One warning is however necessary. If roof trusses are to be calculated strictly in accordance with the loading that will be imposed, and not for a loading greatly in excess, it is imperative that the design should be a sound one, and that it should not involve stresses for which no allowance has been made.

Reference is especially made to a very common fault in design, viz., failure to ensure that the stresses brought to a joint by two or more members, together with any load whether upward or downward, that is applied at that joint, should actually meet at a point. Only too frequently, the stresses are brought together so eccentrically, that surprisingly large bending moments are superimposed on direct thrusts and tensions, with the result that stresses are often two or three times as great as they are intended to be, or need be. With very little care, such secondary stresses can be almost completely eliminated and the truss can therefore sustain a much greater properly applied load than if this point were neglected.

Pump Uses New Principles in the Elevation of Liquids

From The Surveyor, London, Nov. 21, 1919.

An engineer is inclined to be skeptical when one talks of new principles in pumping water, inasmuch as water has been elevated as far back as the history of man can be traced. Nevertheless, the Chaine Helice liquid elevator, exhibited at Stand No. 9, Row C, by Messrs. Boulton & Paul, Limited, at the Royal Agricultural Hall, appears to employ principles not hitherto used for the raising of fluids.

This apparatus encompasses its objects without the use of pipes, valves, buckets, or any of the other mechanisms with which hydraulic engineers are familiar. Its analogy with the ordinary chain pump is only superficial in that, although both are built up on an endless chain, the elevation of the liquid in the chain pump depends on the employment of cups or buckets in every instance. In the Chaine Helice apparatus the endless chain is surrounded by coils of wire which move with the chain, being fixed to the latter at frequent intervals. The spiral chain is suspended from a grooved pulley, by means of which motion may be imparted to the chain and the lower end dips into the well about 2 ft.

When rotary motion is imparted to the grooved pulley, either by hand or power application, the suspended spiral chain, which is kept taut by a counter-weight pulley hanging freely in the loop at the bottom, ascends filled with water on one side, the water being held in the chain by force not hitherto used for liquid elevation. Capillary attraction causes drops of water to stick in the spiral, and as there is a continuous spiral of such drops a sort of skin is produced, which one might term a reinforced water-pipe, the reinforcement being the steel spiral which holds the tube of water together. This would account for the lifting of part of the fluid that is raised. This pipe is, however, filled with water, which cannot escape laterally, and which can only run downwards. Owing to the fact that the core of the spiral is a link chain, and that friction is purposely introduced in other ways, the included water has difficulty in running backwards, and as the chain is being pulled up much faster than the liquid can run back the net result is a continual rise of water, the diameter of which is that of the outer spiral, and the speed of which is the speed of the chain less the backward motion of the water. As the spiral passes over the grooved pulley at the top it opens out slightly, and centrifugal force causes the water to be thrown off. It is caught in a simple tank, and cannot run back through the hole, by means of which the chain entered this tank, owing to this hole being surrounded by a sleeve.

To arrive at the efficiency of a pump of this type it should be borne in mind that, owing to the absence of all pipes and valves, the friction encountered can only be that produced by the relative motion of the water within the spiral and the chain. The water held by capillary attraction and adhesion rises without loss due to friction. There is, however, a serious friction in picking up the water, the effect of the chain dropping into the water and out again being to produce eddies, which, of course, represent loss of power. The friction in the apparatus itself at the top of the well is very small and although the novelty of this invention at the present time precludes publication of very elaborate details, it may be said that the efficiency of the elevator is quite good, probably about 50 per cent. The quantities lifted vary with the size of the chain; the largest chain used at the present time delivering 2,500 gal. per hour. The greatest depth from which water is being lifted at present is 300 ft.

Although, as stated, the efficiency is very good, the real merits of the pump lies in its simplicity. There is no fear of freezing, nor does the admission of dirt and grit with the liquid in any way affect the pump. The grit simply is carried along with the water and thrown off at the top. The smaller types of pumps should therefore be very useful in pumping out sumps, trenches, or any temporary work, the apparatus being easily shifted.

British Experiences With Asphaltic Macadam

By H. T. WAKELAM,

County Engineer for Middlesex.

From Engineering, London, Nov. 28, 1919; abstract of a paper read Nov. 21 before the County Councils' Association at the Road and Transport Congress.

The writer desires it to be understood, at the outset, that the term "asphaltic macadam," which forms the subject-matter of this paper, implies that the material covered by the term consists either of (1) pure asphalt, (2) native bitumen, or (3) material obtained artificially from asphaltic mineral oils, and used for the wearing surfaces of roadways. (Pitch and tar compounds are entirely outside the questions, and materials, referred to in the following remarks.)

Early Experiments with Tar Painting Macadam.—As far back as 1906, the writer submitted a paper, on "Tar Painting of Metalled Road Surfaces," for discussion at the annual meeting of the Institution of Municipal and County Engineers, held in London, and gave therein the results of his experiments, in this connection, which had extended over three or four years previously to that date. The writer was one of the first, if not the first, to tar-paint road surfaces in this country, and since 1906, when his remarks, on the value of tar-painting for road surfaces, were somewhat sceptically received, it has come into general use, and is now recognized as a valuable factor in connection with the upkeep of roads.

It has been found, however, that metalled surfaces, even when annually tar-painted, are not sufficiently strong to resist the wear and tear of mechanically-propelled vehicles. Metalled roads, tar-painted each year, have much in their favor and, especially so, where the traffic is light, and railway facilities are difficult in sparsely-populated areas. In many districts, however, this material does not fulfil the requirements of present-day traffic, and, owing to this, the writer was led, with many others, to experiment with different kinds of materials to secure, if possible, at a reasonable cost, something of an artificial nature which would prove equal to the exiguous requirements of the rapidly-developing mechanical traffic.

The First Continuous Section.—To this end experiments were carried out by the writer in the spring of 1907, on one of the most important main roads leading out of London, when selected (continuous) sections of the road, of equal lengths, were resurfaced with the following materials, viz

1. Tarmac.
2. Tarred Clee Hill granite—2-in. gage, mixed with 1 in to ½ in. tarred limestone—consolidated to a depth of 4 in. and tar-painted.
3. Tarred limestone– 2 in. to 1 in material consolidated to a thickness of 4 in. and tar-painted.
4. Tarred flints, 2¼-in gage, with 1 in. to ⅝ in. tarred limestone and tar-painted.

The materials laid on Sections 2 and 4 had a comparatively short life, and were quite unsatisfactory for heavy traffic, whilst Sections 1 and 2 gave better results, but in their turn they were removed and "asphaltic macadam" laid in their place. The latter has proved satisfactory, both from a point of resultant wear and tear, and from the fact that there has been a saving of £227 per annum in the expenditures on scavenging and watering since the asphaltic material was laid on the road. This, with other obvious advantages, points to the conclusion that a large extension of asphaltic work, under certain traffic conditions, may well be looked for. The said materials are impervious, and withstand, to a great degree, the impact and stress of motor omnibus traffic. There are no traces of the effect of the "suction" set up by the use of "twin" rubber tires, which tends so much to the destruction of ordinary metalled road surfaces by omnibuses, and other mechanically-propelled vehicles.

Asphaltic Macadam Experimental Pavement.—Asphaltic materials are easily cleansed, and there is no absorption of animal urine, or open joints, or interstices, in which excrementitious matter may accumulate and decompose, to get blown about to the detriment of the public health.

As stated above the materials experimented with were removed, and a length of about 5 miles of road surface was covered with asphaltic macadam in about 11 weeks.

The work was carried out by two well-known firms, who guaranteed it for a period of ten years. The initial (prewar) cost was 8s ($1.92), per square yard, plus a maintenance charge of 2s. 3d (54 ct.) spread over the ten years period.

The analysis of the surfacing work carried out (on a Mendip limestone base) was as follows:

	Per cent.
Bitumen (soluble) CS_2	11.50
Passing 200 mesh	16.30
Passing 100 mesh	13.40
Passing 80 mesh	7.50
Passing 50 mesh	38.90
Passing 40 mesh	4.00
Passing 30 mesh	2.70
Passing 20 mesh	2.30
Passing 10 mesh	2.40
Retained 10 mesh	1.00
	100.00

The base on which the surfacing work was laid consisted of a bed of graded Mendip limestone, mixed with bituminous material, covered with asphaltic macadam, as a wearing coat, to a finished thickness of 1¼ in., the old road surface being properly prepared to receive it. The contracts were carried out in June, July and August, 1913. Since that time very little money indeed has been expended on the road in the way of repair, and, judging from appearances, the life of the work will be well over the ten years' guaranteed maintenance period.

Specifications for the Asphaltic Macadam Construction.—The following specifications by the writer formed the basis on which the contracts were let:

1. The contractor shall lightly scarify the existing road surface and reform, steam roll, and consolidate the same to the contour required for the new surfacing. He shall also provide where required in this connection, new Clee Hill granite metalling to form a good sound surface for the reception of the asphaltic materials. The best of the old metalling excavated shall be well screened, and if considered suitable, used for filling up purposes. All surplus materials not required, and approved by the engineer for re-use, shall be carted away by, and at the expense of, the contractor, who shall provide the necessary tips for the same.

2. Instructions to proceed with the work will be given as early as possible after the date of the acceptance of the tender by the County Council, but the contractor shall take into consideration any deterioration of the old road surface which may take place during the time which may elapse between the date of the said acceptance of tender and the completion of his contract, and shall carry out at his own cost all necessary repairs to the length of road covered by his contract that may be required during the period.

3. The contractor shall provide and lay, on the prepared surface, a bituminous pavement, consolidated to a depth of 4¼ in., in two layers, in the following manner.

4. The bottom layer shall be composed of broken Mendip, or other approved limestone, varying from ⅜ in. to 1½ in. in size, with the addition of suitable filling, cemented together with Trinidad Lake bituminous composition.

5. The top layer shall be composed of silica of fine grade, Portland cement, and refined Trinidad Lake bitumen, as a cementing agent, all to approval.

6. The materials comprising the surfacing shall be heated separately, after being weighed in definite quantities, and incorporated in a batch mixer, with the cementing agent.

7. The resulting composition shall be delivered to the road in a hot condition, and laid to a contour not exceeding 1 in 36 to 1 in 40, to the specified thickness, and shall be compressed by suitable rollers. Cross-rolling, by a heavy hand roller, shall be carried out at the discretion of the engineer.

8. The contractor will be required to maintain the whole of the bituminous surface for a period of ten years from the date of completion, and the remaining contingent work comprised in the contract for a period of twelve calendar months.

9. Any side, or cross roads, interfered with, shall be excavated, reformed and graded, to accord with the levels of the new work along the main road, and shall be finished off with suitable materials.

10. The contractor shall provide for contingencies a sum equal to 5 per cent of the amount of his tender, such sum to be expended as the engineer may direct. Any portion of the amount remaining unspent, at the completion of the works, will be deducted from the contract when the final statement is prepared.

Causes of Waviness and Corrugation.—In 1914, another important main road leading out of London was similarly dealt with. Both capital and maintenance costs, per square yard, were exactly similar to the figures above quoted.

The company who carried out, and are maintaining, the work, have had no expense, to date, in connection with it, although the road during the war period was (and still is) subjected, both day and night, to an exceedingly heavy motor lorry traffic.

The surfaces of the two roads treated are smooth and hard, and bar the inevitable waviness and corrugation, which is inherent to all kinds of roads under motor traction, the carriageways are in an exceedingly good state—with one excepted short length. The latter is a section about 80 yd. to 100 yd. long upon which the asphaltic macadam was laid, as an experiment, on a 6 to 1 Portland cement concrete bed, 6 in. thick. The writer was of the opinion, at the time, that asphaltic macadam, spread to a thickness of an inch only, on a hard rigid foundation (to which there could be no practical cohesion) would be bound to corrugate quickly and "roll up." The result has fulfilled his expectations! More money has since been expended on the short experimental length, referred to, than on the remaining length of the road, and it has recently been decided to remove the concrete and, in its place, to substitute a resilient bed of limestone, mixed with a bituminous material, and coated with asphaltic macadam, to accord with the remainder of the road.

With regard to the question of "waviness and corrugation" above referred to, much has been said, and written, from time to time on this important point, and many suggestions, of a theoretical kind, have been offered, and have been stated to be both a remedial and preventive measure, in regard to the trouble experienced in this connection. It has been suggested that corrugation is due (1) to bad steam rolling; (2) to faulty spreading of materials; (3) to the use of poor quality binding materials; (4) to inter-attrition; and (5) to the variations in the qualities of the materials used. The ordinary man in the street, would, perhaps, accept any of these as the cause of corrugation, but to practical men, who are daily studying road questions, a solution of the matter is looked for in other directions. Previous to the advent of mechanical traction, as we know it today, roads were steam rolled, the same materials were employed, and their qualities were just as variable as they are now, but corrugations as now seen and experienced, were practically unknown! Corrugations cannot, therefore, with impunity, be attributed to any of the above-named causes. To the mind of the writer the chief cause of corrugation is vibration combined with friction!

Since the contracts above referred to were carried out, the writer has carried out other road contracts of considerable magnitude, totalling many thousands of pounds, in connection with which asphaltic materials have formed the surfacings. In two or three of these contracts, selected clinker from a refuse destructor formed the bottom beds in place of limestone.

Constituents of the Asphaltic Macadam.—The wearing coats laid on the clinker were composed of natural bitumen, sand and cement, as follows:

	Per cent.
Bitumen (soluble) CS_2	11.50
Passing 200 mesh	16.30
Passing 100 mesh	13.40
Passing 80 mesh	7.50
Passing 50 mesh	38.90
Passing 40 mesh	4.00
Passing 30 mesh	2.70
Passing 20 mesh	2.30
Passing 10 mesh	2.40
Retained 10 mesh	1.00
	100.00

The writer has also experimented with a length of asphaltic macadam laid in one coat, on an old granite macadam surface. This experiment is being carefully watched, and notes taken with regard to it.

For the purpose of the experiment, the old metalled road surface was lightly scarified, and adjusted to proper levels, and thoroughly steam-rolled to provide for a single coating of refuse clinker asphaltic macadam, which was prepared in the neighborhood of the road on which the material was laid.

The formula of the proceeding was as follows:

7.3 cu. ft. of fine clinker refuse residual about 482 lb. in weight.
68 lb. of Portland cement.
65 lb. of ¼-in. Clee Hill granite chippings.
65 lb. of fine clinker retained on ⅛-in. screen and passing ⅜ in.
155 lb. of Trinidad bitumen.

ANALYSIS.	Per cent.
Bitumen (soluble) CS_2	13.60
Passing 200 mesh	18.00
Passing 100 mash	8.60
Passing 80 mesh	1.65
Passing 50 mesh	16.15
Passing 40 mesh	4.30
Passing 30 mash	3.70
Passing 20 mesh	5.40
Passing 10 mesh	7.80
Retained 10 mesh	17.80
	100.00

Chief Essentials for Success in Asphaltic Macadam Construction.—Asphaltic macadam is now being so much used, and its component parts and mixing are getting to be so well understood that it would be superfluous, to some extent, to give more details in regard to it in this paper. The chief essentials to success in its use are, primarily, the character of the bitumen used, and the density (i. e., freedom of voids) of the final mixture. If it were not for the extreme changeabilities of the English climate, it might be possible to adopt varying standards of asphaltic macadam for surfacing work in this country, but as it is most essential to exercise the strictest carefulness in all such operations, each road must be considered in accordance with its requirements. Some standard compositions have been formed to withstand heavy traffic in the summer months, but they have failed completely in the more trying seasons of the year, and, especially so, during the severe climatic conditions which prevail in this country, from October to March, which have shown that the employment of low standards accounts greatly for the failures so frequently experienced. This important factor should not be lost sight of by those who are wishful to secure satisfactory and lasting work.

In actual practice it has been found that fine sharp sand, in proper proportions, is one of the best materials that can be used as an aggregate in connection with pure bitumen, for road surfacing. Its use has now been well established, but care must be exercised to obtain suitable distributions of the sand over a range of meshes—say one-tenth of an inch to a hundredth in size. Such a distribution should secure the requisite density. Sands which contain impalpable matter, clay or organic impurities, should be avoided. Clayey matter adheres to the coarser sand particles, during the process of heating and drying, with the result that the subsequent coatings of bitumen are much depreciated in value. Angular quartz sand has been proved to be the most suitable aggregate, but there are local sands in various parts of England, Ireland, Scotland and Wales, from which typical gradings may be obtained.

With regard to the preparation of asphaltic macadam, it is important, and necessary, to obtain what is known as a suitable "filler." The function of the latter is to increase the density of the bitumen covering the sand particles used, and to close the finest voids. For this purpose Portland cement has proved itself to be the most effectual material, owing probably, to its inertness in combination with bitumen, and its specific gravity. The "filler" used in asphaltic compounds forms a great desideratum in connection with the life of the material, under traffic conditions, and its qualities call for the most careful consideration.

In departing from the time-honored use of waterbound macadam (tar-painted each year) for which material there is still, and undoubtedly will be for many years, a great call, it is reasonable to consider the most suitable thing to adopt in order to meet and resist, the abrasions, stress and attrition of modern traffic. The later is bound to increase on mechanical principles, and it useful to consider in what way, and with what material, the more important roads of the country are to be maintained. The writer has given this matter much attention and has outlined herein his own procedure.

Industrial Fatigue—Theory and Practice

By MAJOR E. A. PELLS.

From Engineering and Industrial Management (London), Nov. [illegible] 1919.

It is always pleasing to both theorists and practical men when theory and practice show confirmatory results. Therefore the following instances must be of pleasing interest to all efficiency men who have devoted any time to the study of Industrial Fatigue and all allocation and arrangement of equitable rest factors.

Figure 1 shows a theoretical diagram based upon medical fact, representing the useful work cycle of any operation necessitating the expenditure of human energy. The horizontal divisions equal units of time, the vertical divisions units of effort; the squares enclosed, therefore, show units of work.

The theory is that when any kind of work is commenced an effort is put forth which equals O.M.; the energy expenditure then lags slightly, dropping to N, after which it rises to point B, continuing along this line until the fatigue effects commence to show, when the effort curve rapidly drops away, following the line C.F.L., when it would finally run along a fairly level line until the arrival at leaving-off time or the cessation of work through complete exhaustion.

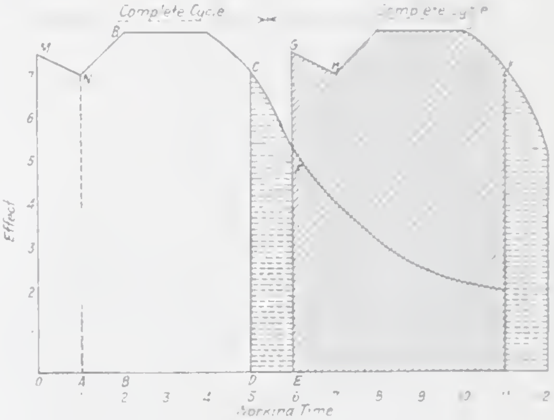


Fig. 1—Theoretical Diagram of Useful Work Cycle.

It is necessary now to determine at which point the rest period should be brought in, and theoretically it should be on the dropping curve at C, as being the point coinciding with N, which is the lowest point on the useful effort line.

Work should recommence when the workers have recovered sufficiently to bring their initial effort up to point G which is coincident with point M, and is equal to their first energy expenditure.

The actual length of the rest period is directly dependent upon the character of the work and the amount of energy expended, but in the diagram shown it is a sixth portion eqnal to 20 per cent of the working time. We therefore see that the shaded area F G H I J K L shows the saved energy due to the rest taken shown dotted C D E F

It is therefore obvions that rest is taken when performance D C = A N, and rest continues until performance at recommencement E G = O M, and it is correctly fixed when area F G H I J K L exceeds C D E F

Now let us consider what the actual gain in conserved energy amounts to when it is based upon the foregoing.

Considering the diagram in Figure 1, each square enclosed in the diagram equals a unit of work or possible work; on consideration we find that

	Units of work
Work done with rest factor	76.75
Work done without rest	[illegible]
Gained by using rest	[illegible]

This therefore shows a gain of [illegible] per cent.

We now turn from theory to practice.

Figure 2 shows four representative output curves for different gangs of men engaged upon very laborious work, working on a piece rate and from starting time to dinner time and thence right through to leaving-off time. It is very noticeable how all the curves coincide in their principal characteristic, and that is, the tremendous drop towards the leaving-off times, after two hours' work in the morning and after only an hour's work in the afternoon, clearly showing that the men became overfatigued in the morning and were therefore insufficiently rested at the afternoon start.

After study of the energy expenditure it was decided to give a 23 per cent rest factor, to take effect after each 45 minutes work, a rest of 15 minutes to be taken; this appeared at first glance to be a very liberal rest, but the result was most astonishing and the resultant outputs are shown in Figure 3. It will be observed that a steady output is maintained and is more of a rising curve as the leavingoff time approaches, proving that the men were not at all overfatigued and had, in fact, some stand-by energy to expend.

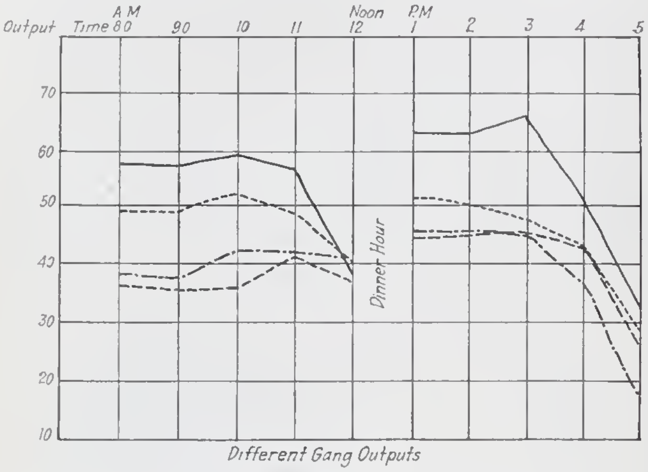
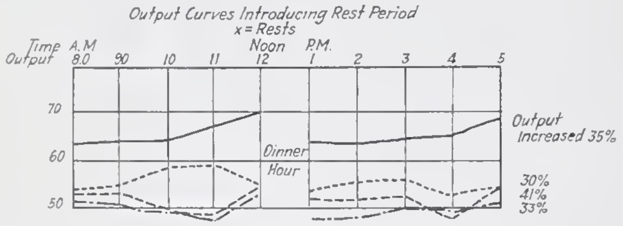


Fig. 2—Representative Output Curves.

We notice, too, that the improvement in output was round about 30 per cent, which coincides very closely with the 28.3 per cent on the theoretical diagram. It is particularly noticeable that the giving of the rest has equalized the output over the day, which proves that working with a properly defined rest period keeps extreme fatigue at bay and enables the workers to increase production at a less expenditure of energy.

It is interesting, too, to know that the workers declared that the knowledge that the rest period was coming along enabled them to start off with a greater energy expenditure, because they had not the feeling that they must conserve their strength because of the long spell of work in front of them before leaving-off time.



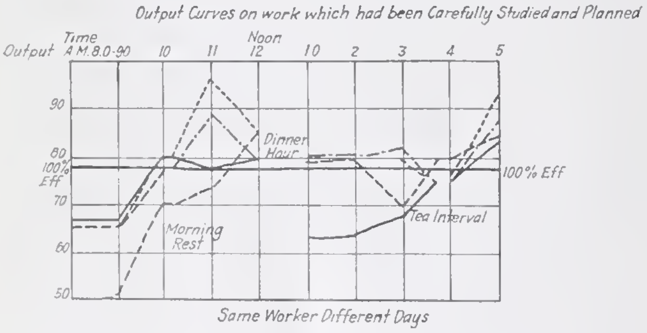


Fig. 3 (Upper)—Effect of Rest Factor on Output. Fig. 4—Output of Gang of Workmen on Same Operation on Different Days.

In most work of a light character, one finds that quite a short rest is sufficient, 3 to 5 minutes every hour being ample, but when the signal for the rest is made, it must be insisted that all workers who are working in a standing position must sit down, and where sitting should get up and move about. In fact, it has been considered sufficient in some cases, where the work is light and not of an exacting character, to simply make the workers stand and sit alternately for definite periods though it must be recognized that so long as the worker is carrying on with the work there is a certain nervous tension, and the relaxation of only two minutes is a welcome tensional relief.

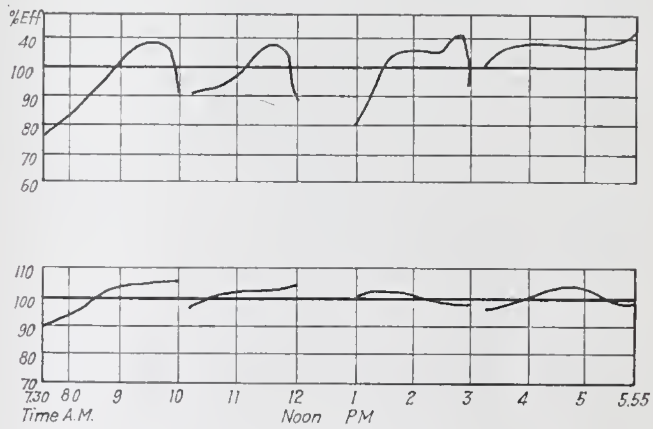
Figure 4 shows what can be done by a careful initial study of work so that the method at the commencement is carried out along right lines, for there is not the slightest doubt that if the workers are started away on the right methods it is much better than having to break them of formed habits of an inefficient character.

This diagram represents the outputs of a gang of female workers carrying out the same operation on different days, and it will be noticed that the work was going with a swing and commendable steadiness of production. These workers were working on a time rate of pay and it was simply the fact that the conditions were good and the workers quite content that enabled such a degree of efficiency to be attained.

It will be noted that these workers achieved 100 per cent efficiency on the day's average output. As a comparison it is interesting to know that the same work was carried out elsewhere under conditions of labor and rest decided by the workers themselves, and although the same appliances and arrangement of carrying out the work obtained, the degree of efficiency compared to the same standard was only 65 per cent. Here, again, we find that the correctly arranged rest factor made a difference of 35 per cent on the output.

When studying the question of industrial fatigue one has to be careful to consider the matter from two standpoints.

We have to consider principally the purely physical effect of fatigue which accrues in all cases where work entails definite application of either real muscular or mental effort. The fatigue in the latter is often greater than the former, and the necessity may arise in some instances for quite as high a rest factor as for the muscular tiredness.



Figs. 5 and 5A—Output Curves of Two Workers Carrying Out Repetitive Bench Work.

As an illustration of what I wish to convey, Figures 5 and 5A show the output curves of two best female operatives carrying out repetition bench work of a light character. These girls were paid on a premium bonus system and each regularly earned bonus, but on examining their rates of output it is astonishing to find that, whilst one is evidently a steady, level worker, the other seems to work in spurts, and just at the end of the day runs away with the work and makes a fine finish. The operative whose curve is shown in Figure 5A is no doubt the best for study purposes, as the other operative is evidently a most erratic worker, and any decisions arrived at through the study of her output rate would be very misleading.

The better to study fatigue on production jobs a system of output record cards was instituted on which the output was entered either every fifteen minutes or some other even period. It was found that the workers displayed a great deal of interest in these, and the mere fact of their work being recorded as they went on during the day was in itself sufficient to cause an increase in output. This is a psychological result similar, in fact, to the better times that are shown in races that are paced, or where there is a sufficiency of good class competitors to make a good race.

So we find the competitive spirit entering into the question, and each worker endeavoring to be better than the next. Here, then, is a means by which production may be increased, even although the new methods may not be put in to do so, for the spirit of emulation is strong in the human breast, and so long as the worker can see how he or she compares with their confréres, so will we have that extra effort put forth to do as well.

The foregoing facts must be pleasing to any student of the question of industrial fatigue, and although progress has been made in this great study which has as its ultimate aim the elimination of the waste of human effort and the humanizing of industry, yet there is much more to be done in the way of research, such as that which has been carried out by Major Gilbreth and his accomplished wife, and the encouragement of early successes should not just satisfy but spur us on to further effort to improve the conditions and methods under which our fellow creatures labor.

Concrete Pavements in New Zealand

By WALTER E. BUSH,
City Engineer, Auckland, New Zealand.

From Engineering, Nov. 28, 1919, of paper read Nov. 21 before the County Councils' Association of the Roads and Transport Congress.

In the course of his official duties the writer submitted a report to the City Council, Auckland, upon the streets of the city, dealing, inter alia, with the relative merits of various forms of paving, in which he stated his belief in the future of concrete paving for climates like that obtaining in Auckland, especially as motor traction would tend more and more to replace horse traction in the future, and in respect to a number of streets he gave alternative estimates for paving such streets in compressed asphalt, wood block, stone setts and concrete. It was not, however, until the latter end of 1915 that the City Council authorized him to put down the first cement-concrete pavement in the city, although cement-concrete foundations had been put under all paved streets. The measure of success met with in the first street has led to its increasing use, and practically all streets that have since been permamently paved have been carried out in cement concrete, and when the writer left New Zealand in March last, some 35,000 yds. in all had been completed, 14,000 yds. were in hand, and an additional 135,000 yds. had been authorized.

The first street to be paved was Little Queen street, 423 ft. in length, and lying almost due north and south, so exposing it to the suns rays for the middle part of the day, which means in summer time that the surface temperature is often as high as 120° F., and may sometimes exceed that. Its mean elevation is 9 ft. above sea-level, and it serves the back or cart entrances of a number of warehouses and works to and from which traffic is of the heaviest description, both two and three-horse lorries and also motor trucks being used, carrying the largest loads that the very flat grades on the water front make possible, and it is also subjected to much turning and twisting of traffic from the fact that many of the warehouses have cart docks, and practically all unloading is done by backing the lorries and trucks either into such cart docks or against the kerb.

The street was prepared for paving by scarifying the waterbound macadam, excavating to the required depth and preparing and rolling the subgrade to the required camber to receive a uniform thickness of 8 in. of pavement, with a fall from the crown to the channel of approximately 1 in 36.

Two-coat work was adopted, the lower 6 in. of 7 to 1 concrete and the upper 2 in. of 3 to 1 concrete. The 7 to 1 concrete consisted of 5 parts of clean beach shingle having a fair proportion of sand, two parts of broken basalt between 1-in. and 2½-in. gauge, and 1 part of Portland cement (New Zealand manufacture), while the 3 to 1 concrete consisted of 2.25 parts of beach shingle, 0.75 parts of ⅜-in gauge basalt chipping and 1 part of cement. The top 2 in. was laid immediately after the lower 6 in. had been roughly brought to its proper shape, and while it was quite green, so as to ensure that the whole 8 in. was practically homogeneous.

The surface was brought to a proper camber by a straight timber template shod with steel, operated transversely to the longitudinal axis of the street, from the center to the channel, on screeds of angle iron fixed to bars in the ground, after which it was steel trowelled till it presented a flat even surface; after setting had commenced it was lightly broomed to remove glazing of any portion of the surface, and when setting had taken place the surface was covered with bags and kept wet for eight or nine days.

It being midsummer, only three weeks was allowed before the paving was opened to traffic. It was then allowed to carry the traffic for nine months, before being treated with Californian asphalt, brushed on hot and dressed with screened beach shingle.

Prior to the application of the asphalt dressing the surface showed slight signs of wear in one or two places where the quality of the shingle had not been so good as in the remaining portions, a fact which emphasises the necessity of only using the best qualities of aggregate available in this class of pavement.

The next street (Durham Street) was done with one-coat work 7 in. thick of 5 to 1 concrete, the traffic conditions not being so severe as in the first-mentioned, and it was left untreated and has stood quite satisfactorily since its completion in October, 1916.

The third street to be paved in concrete (Park Road)) forms a portion of Auckland's busiest traffic outlet, and lies immediately eastward of the important reinforced concrete viaduct known as Grafton Bridge, which is surfaced with compressed Neuchatel asphalt.

It carries mixed traffic, most of which is fast traveling, and includes heavy petrol motor wagons and char-a-bancs, but no motor buses similar to those so common in London the number of vehicles counted being over 2,000 per day of 10 hours.

The work was done in two halves to prevent stoppage of the traffic, and was much delayed by difficulty in obtaining shingle owing to bad weather, and this resulted in some shingle being used which was not absolutely first-class and also in the street being opened up for traffic sooner than was advisable, and it caused the writer to cease using shingle for aggregate and to substitute therefor broken basalt and sharp sand, as he came to the conclusion that the desire of the inspector and foreman on the job to get on with the work might prejudice their judgment in deciding as to the suitability of shingle brought on to the job, while the basalt and sand he could practically ensure the obtaining of a standard of quality.

The alteration was made during the progress of the Park Road job, which was a one-coat pavement of 5 to 1 concrete, 8 in. thick, and the bays done with the basalt and sand aggregate showed enough superiority to the rest of the work to justify his conclusion and he has since found no reason to modify it.

With the exception of a short length of the basalt and sand concrete, the whole surface was treated with a dressing similar to that used on Little Queen Street.

In addition an area of over 2,000 sq. yd. in Pitt St., on which trial lengths of proprietary bituminous pavement had been laid on a 6 in. concrete foundation and had failed, was surfaced on the old concrete foundation with a rich concrete (3 to 1), half of the area being an average thickness of 3 in and the remainder 3½ in. This was only completed in March last.

In all the streets paved since 1917, the paving has been one-coat work of concrete, composed of clean basalt chippings and screenings varying from 1¼ in. gauge to "fines" mixed with 25 per cent of sharp beach sand free from shell and gauged with Portland cement in the proportion of 5 of aggregate to 1 of cement, but prior to the concrete being laid the subgrade is sprinkled with 2¼-in. clean basalt road metal as a measure of economy. In all cases the subgrade is carefully prepared and rolled solid, and steel rod reinforcement is laid transversely over trenches likely to cause trouble by subsidence.

The concrete is mixed by machine, one gang using a "Eureka" continuous self-mixing type and the other a 7 cu ft. "Koehring" batch mixer fitted with boom distributing hopper. Both machines have given fair results, but neither is ideal, the writer preferring a "batch" to a "continuous" mixer, and in the case of the batch mixer one of the larger capacity; but he had to take what was available at the time.

On the question of hand versus machine mixing he has a decided preference for the latter, and is surprised that so few are being used for concrete work in street foundations in this country. In America their use is universal, and on both counts of economy and efficiency he would strongly advise their adoption.

Dealing with the much-discussed question of joints the writer has adopted the use of tarred paper, folded to form two thicknesses, and these are placed approximately 56 ft. apart, the length of bay being laid 14 ft., and four bays a convenient length for a joint.

Out of 35,000 yd. laid, of which only 5,216 had been coated, not a single crack had been discovered between the bays, and only in Little Queen St. and Park Rd., in which shingle concrete was used, were there any noticeable signs of wear. The tarred paper joints and those formed by the junction of two bays are coated with asphalt and fine shingle.

Where concrete paving is laid in streets with tramway tracks, a longitudinal wall, 9 in. wide and as deep as the bottom of the tram track foundation, is put under the pavement 18 in. from the outer rail, to prevent disturbance of the pavement when the track, mostly laid on sleepers, is being packed or repaired. A stone set margin is used to separate the pavement from the portion of road occupied by the tram track, which is surfaced with bituminous macadam, 2 in. thick, laid on waterbound macadam in the margins and between rails and well rolled.

The cross fall adopted is 1 in 36, unless special conditions necessitate a variation.

The method of finishing adopted has been similar to that used in the case of Little Queen St., but now a belt is being used with good results.

Arising from his experience in carrying out concrete paving the writer desires to emphasize the adoption of the following precautions:

(a) The thorough preparation of the subgrade or foundation, including the use of a suitable steel reinforcement over trenches or holes where subsidence may take place.

(b) The use of the very best quality and uniformity of aggregate and cement, and their thorough mixing, with as small a quantity of water as is necessary to ensure density of mass and smooth finish.

(c) The utmost care in the tamping, screeding and troweling of the pavement.

(d) The keeping damp of the concrete during the process of settling and hardening.

(e) The allowance of ample time for setting—never less than three weeks in summer and four in winter or damp or cold weather, and preferably longer, before traffic is allowed to use the pavement.

Reconstruction Work in France.—The Paris correspondent of The Engineer reports in the Dec. 5 issue, that there is a feeling of some irritation at the delay in giving out contracts for reconstruction in the devastated regions. The roads, railways, and bridges have had to be rebuilt, and this preliminary work is now well advanced. Then a vast amount of clearing up will have to be effected by the Germans, of whom about 70,000 are said to be now arriving in the north of France. A considerably larger number will follow shortly. Big contracts are hardly likely to be distributed until the general scheme of reconstruction has been settled with the Germans, and the question will then arise of how all the material will be supplied, for if there is so much difficulty in providing what is necessary for temporary constructions it is feared that the problem will be a very serious one. The greatest trouble is the lamentable falling off in railway efficiency. There is no lack of rolling stock, for with the locomotives and wagons purchased from Great Britain and the United States and surrendered by the Germans the companies are better off now as regards quantity than they were before the war, and, although a large proportion is in bad condition and in need of repairs, there is certainly sufficient rolling stock to meet present emergencies if only the organization were not so defective. The trucks always happen to be just where they are not wanted. Some of the ports have become so congested that it is a serious problem to know how to clear the goods away. At one colliery there is so much coal at bank that mining operations have had to be suspended.

The Institution of Civil Engineers and the War.—Thirty-six per cent of the membership of the Institution of Civil Engineers served in either the British Navy, Army or Air Force during the war. The total number in service was 3,127, of which over 10 per cent were killed.

Development and Storage of Water for Hydro-electric Projects

By J. W. MEARES.

From Water and Water Engineering, London, Oct. 26, 1919.

With a stream generating station the main considerations in fixing a site are facilities for condensing water and for fuel delivery and ash removal. None of these operate in the case of hydro-electric plant, which must be placed where the ground admits, and designed to suit it. Thus it may happen that a high fall cannot be developed conveniently as a single station, but can be utilized in the form of two stations in series, the tailwater of the one discharging into the headworks of the next. This has been done at the two Santa Ana Creek stations at Redlands, Calif., and in the small developments at Darjeeling, India, which the author carried out in 1896, the method has been used for subsequent extensions. Figure 1 shows the varieties of hydraulic lay-out met with in practice, as described in the following notes.

High Head Lay-out.—High-head schemes are necessarily located in mountainous country, and are generally fed from torrents of small volume, liable to heavy flood and consequently bringing down much mud as well as gravel and large stones. Even if the headworks have a dam it is generally necessary to have settling tanks and a forebay, in order to prevent damage to the wheels from foreign matter traveling at high velocity. In order to get the most suitable fall with as short a length of pressure pipe as possible, it is almost always necessary to carry the water along the hillside for a considerable distance in an open channel (Fig. 1a), generally of artificial construction, though occasionally merely a cutting in earth. The channel offers a weak link in the chain, and duplication is impossible, though occasionally two or more separate sources of supply may be tapped by different routes. To allow for fluctuations of load (apart entirely from the question of settling tanks) a forebay at the head of the pressure pipes is essential, unless water is so plentiful that an excess is always running to waste at that point. The forebay must be of such capacity that it will supply the excess water, over and above what the supply channel brings, at the time of peak load, or in the case of sudden heavy loads (e. g. short-circuits) thrown on the station. If the forebay is too small, and runs out even momentarily, air will get into the pipes and water hammer will probably follow when they refill.

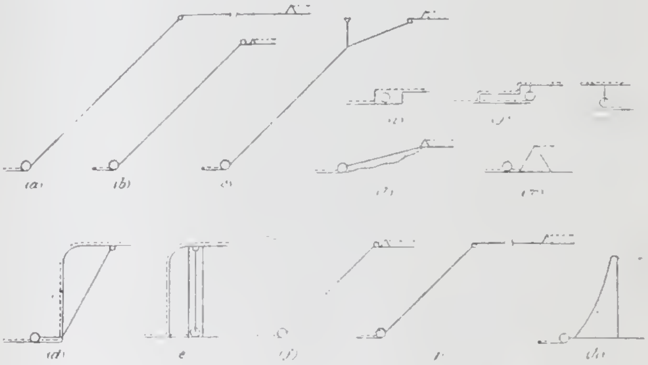


Fig. 1—Hydraulic Layouts.

Thus if the channel can deal with a steady load of 2,000 kw., and the peak load averages 2,500 kw. for 2 hours, there must be at least 1,000 kw.-hours stored in the forebay. On 1,000 ft. head this amounts to about 56,000 cu. ft. This amount, however, is of no practical use as a reserve against a temporary breakdown in the channel or at the headworks, and wherever possible a scheme of this nature should have enough storage at the pipe head to tide over at least a few hours' stoppage from such causes. For this, much greater capacity is necessary, and it may not always be possible to provide it. If the ground will allow no more than a regulating forebay, a reservoir must be constructed elsewhere, and the nearer to the pipe head the better. If, however, large-scale storage by means of a dam is possible it will almost always necessarily be either up-stream of the headworks or at them, and the chances of a break in the flume must be risked. Large reservoirs, constructed by means of dams, can obviously only be located where the ground offers natural facilities, i. e., at a comparatively narrow neck in a valley, which opens out above and does not rise steeply. Where comparatively small storage is required more latitude is found. In some cases of steep ground it is possible to locate the powerhouse so near to the headworks, even with high heads, that the water can be carried in pipes the whole way, without an open channel (Fig. 1b). Here the risk of breakdown is a minimum. An intermediate case between these two extremes is where the distance from reservoir or headworks to powerhouse is considerable, but a channel cannot be constructed owing to the slope of the ground. Generally the steep fall will be at the lower end of the pipe line, and the upper reaches will fall very little. In America the usual method of dealing with such problems is to use wood stave pipes from the upper part of the pipe line, with a surge tank at the junction of these with the steel pressure pipes, where the steep fall begins (Fig. 1c). The surge tank consists of a reservoir, elevated to the level of the water where it enters the stave pipes, connected by a large pipe (or separate pipes) to the junction. It not only serves as a regulating forebay, giving the water in the comparatively level upper section time to alter its velocity, but also it taken up and relieves all jars that might damage the weaker sections above it.

Medium Head Lay-outs.—Medium heads will generally be developed either from actual waterfalls or rapids in rivers, or from rivers near the base of mountains where the volume is great and the slope comparatively small. Higher up-stream it is generally possible to utilize a high head at less cost, even though a large volume may be available. Where many rapids occur in a short length of bed it may be possible to pipe the water direct from the stream to the powerhouse (Fig. 1d), with a forebay interposed to prevent detritus getting into the pipes. In several American schemes either the whole powerhouse is located at the bottom of a shaft cut down vertically in the rock behind the fall (Fig. 1c) or the turbines are placed in such a shaft and operate generators on the surface. Where there is an actual waterfall, as in many of the largest undertakings, it is seldom necessary to carry the water far to the forebay. Sometimes the pressure pipes can be led directly into the reservoir (Fig. 1f) or into a forebay constructed immediately above the fall. A short canal at most is required, and as it must be of large carrying capacity there is a great saving in such a natural fall.

Where the river has a considerable bed slope, or rapids, it may be necessary to carry the water for miles in a canal (Fig. 4g) in order to accumulate a few hundred feet of fall; and if an earthwork canal is impracticable an artificial flume is required, which adds both to the capital cost and to the liability to breakdown.

As the head decreases, and the column of water increases, not only the flume but also the pipes increase in size, so that carriage to site often becomes a difficult and expensive problem where the installation is some distance from the railway. Occasionally a medium-head plant may be worked directly from a reservoir behind a high dam (Fig. 4h), but in such cases there will obviously be very large variations of head to contend with, sometimes with full head to none at all. Sometimes—in fact, generally—such a reservoir will have been built primarily for irrigation purposes, so that beyond a certain minimum the flow is strictly regulated according to season. This detracts from the commercial value of any such scheme.

Low-Head Lay-outs.—Slow-running rivers and canals, with a small bed slope and no falls, cannot ordinarily be used for power purposes, as it is not possible to develop even a low fall without the risk of flooding the surrounding country above the dam; while the rise and fall of both head and tail waters, not necessarily to the same extent, further complicate the problem. Even where a small fall exists or can be made, these factors complicate the design.

In the case of irrigation canals, falls of from 3 ft. to 10 ft. are not uncommon, and can be developed by taking a feeder channel as a by-pass to the powerhouse, continuing as the tail race back to the canal below the fall (Fig. 1i). Sometimes a subsidiary canal (generally in the form of a tail race) will enable two neighboring falls to be combined so far as the turbines are concerned (Fig. 1j). Larger heads but still of the low type, may occasionally be developed, where irrigation requirements permit, by discharging part of a high-level canal through turbines to a low-level canal (Fig. 1k). All irrigation canal projects suffer from the disadvantage that an occasional closure is necessary—whether for purposes of repair, or because the water is not required, or because it is more urgently required elsewhere.

In the case of rivers, low falls may be developed on the lines already described for medium falls (usually a Fig. 1l)—always bearing in mind the ever-increasing size of channels and pipes as the fall decreases. In addition there are various schemes in which a dam is placed across a river not so much with a view to storing water as for the purpose of obtaining head. Here the water is fed directly from the dam to the turbines (Fig. 1m), which in some cases are packed inside a hollow dam.

Great variations in the level of the head and tail waters are often a feature of low-head river developments, and floods are a serious menace. In some cases, e. g. at the station of the Portland Railway Light & Power Co., Oregon, and at Bhatghar Dam plant in Bombay Presidency, double turbines are installed, one for the maximum head and the second for the reduced fall. Flood gates, as used in irrigation canal headworks, are required to deal with abnormal rises

Headworks and Clear Water.—There is always present the liability of bringing down mud and débris from the source of supply to the turbine wheels, though in the case of canals this is not of great importance from the point of view of power development. This liability increases with the head, as torrents take the place of larger rivers, and its effect on the wheel buckets also increases with the head and the spouting velocity of the jet or nozzle. Even the finest grit under a head of 1,500 ft. or 2,000 ft. is most destructive, and loss of efficiency soon results from worn nozzles.

Where the headworks have a considerable dam there is no danger from stones or heavy matter except that their deposition will reduce the capacity of the lake; but in hill torrents this in itself is so serious a matter that high dams would seldom be justified. Such a lake could only be cleaned out at great expense, though undersluices may enable the débris to clear itself if there is enough water to spare and if the lake is only of moderate size. If, however, such a dam is necessary it will sometimes pay to put another and smaller one farther up-stream, simply as a means of arresting the silt for a few years. The capital charges would generally be less than the cost of periodical cleaning out. With lower velocity in the stream such dams are often practicable, though not necessarily at the point where the water is tapped off.

On High and Medium Heads.—Generally speaking, in the case of high and medium-head plants, a low diversion dam is all that is necessary, sufficient to ensure the possibility of getting the water into the channel or pipe under normal conditions, and also to protect the stream at this point from scouring out the channel and endangering the supply in times of flood. Cases have occurred within the author's experience where a few days' abnormal rainfall have lowered the level of a stream bed 30 ft. or 40 ft. For protecting the banks above and below the headworks boulder crates, made up of large boulders enclosed in a framework of heavy-gauge galvanized wire, have been found invaluable in every sort of river training works. Cases will sometimes be found where a permanent dam is not necessary, the natural lie of the ground alone ensuring the supply. Timber dams are sometimes used in America for leveling the bed.

In the absence of a dam, whether the water is taken direct into pipes or into a channel—but more especially in the former case—arrangements must be made at the headworks for catching all débris. Generally there will be a succession of screens or trash racks through which the water passes to a small tank, in which any heavy matter coming through will deposit. This will need constant cleaning out, and should (in the absence of other reserve) be in duplicate. Nothing but fairly fine silt should pass beyond it. If there is no open channel this tank should be large enough to remove even such silt as will deposit readily, or there should be an adjoining settling tank for this purpose. Where there is an open channel there will always be the liability of further débris being collected along it, and a forebay is necessary at the point where the pipes take off. Sometimes the lie of the ground makes it convenient to put intermediate silt tanks along the route. All these should be designed for rapid clearance at several exits, controlled by gates of substantial size. By sloping the floor from all points towards the exits the flow may to a great extent be utilized to carry off the deposited mud. The size of these settling tanks should be such as to reduce the normal velocity of flow to a few inches per second. Where there is a reservoir at the pipe had it is still necessary, as far as possible, to prevent the accumulation of mud in it, as a large volume will become so solid that its clearance is a matter of difficulty, and a silt trap immediately before it will assist in this direction. Where water is considerably in excess of actual requirements it is possible to allow a proportion to run off continuously at the headworks chamber, through partly open sluices, which will pass out all solid matter rolling along the bottom.

On Low Heads.—In the case of low heads the water is generally clear, as low velocity postulates a small bed slope and deposition will occur in the river itself. In any case the quantity to be dealt with is so great that artificial settling cannot be arranged for. Strainers (known in America as trash-racks) are necessary to prevent floating matter entering the pipes, and a forebay may be required to catch anything that may pass through, as well as for regulation. A long canal is seldom necessary, and the forebay will either be at the side of the fall, parallel with the river, or across it on or in a low dam. It depends on the ground whether a diverting dam or anicut is required, or whether a forebay can be opened directly into the bed of the river. In the majority of cases of very low heads the power station is built across the river, and the water flows directly through the strainers into the turbines. In America much trouble is caused by ice on such plants, both from floating blocks and from ground ice (or frazil, as it is called there) which forms suddenly from super-cooled water where its velocity is checked at the gates. This is dealt with by steam pipes and sometimes even by explosives, and may cause complete stoppage.

Institution of Civil Engineers: Local Associations and Registration of Engineers

Abstract of presidential address of Sir John Purser Griffith before Institution of Civil Engineers.

Although filled with admiration of the broad lines upon which this institution was framed, we must not shut our eyes to the changes which have taken place in the status of our profession. The field of our members' work is now world-wide. The membership of all classes, which was 156 when the charter was granted on June 3, 1828, exceeded 9,000 before the war, while the subjects dealt with by the civil engineer have multiplied with every advance of scientific knowledge.

It stands to reason that in the face of the numerical increase of our members, their world-wide influence, and the ever-extending field of their services, the scope of our institution's duties and activities must expand. It is our duty to endeavor to make this institution as useful to its 9,000 members as its founders made it for the 156 members on its roll when it received its royal charter. If we accept this view, we must listen to our members when they put forward proposals in what they believe to be the interest of our professional corporate life, and be prepared to consider and carry them out, if we feel that they will strengthen the bonds of professional brotherhood, although they may appear to conflict with our conservative traditions.

Two questions of importance to our institution and to our profession have come before your council during the past year. The first is the desirability of forming local or provincial associations of corporate members for mutual intercourse, and the furtherance of their professional knowledge and interests. The second, whether the time has come for seeking legal recognition of the profession of the civil engineer, and the registration of engineers.

Local Associations.—The case in favor of the formation of local associations in union with the institution has been brought under our notice by an influential deputation of members from the Midlands, who presented their case in a conciliatory and friendly spirit. The desire for local associations, recognized by the institution, appears to be a natural and reasonable development of the student associations, already established in Glasgow, Manchester, Birmingham, Newcastle-on-Tyne, Yorkshire, Bristol, the West of England, and South Wales. The success of these student associations is undoubted. They have taught our young men the advantages of professional intercourse, both from its social and professional side. At the age of 26 the student ceases to be a member of the association, and if he wishes to retain his connection with the institution must seek admission as an associate member. In this manner a large number of corporate members, scattered throughout the country, cease to gain the advantages of association which they had as students. This, I think, explains the present craving for the formation of local associations. I cannot help feeling that their formation will be a distinct gain to the institution, if the links binding them to the parent institution are wisely forged. We must bear in mind that our membership is close on 9,000 in number, that our minutes of proceedings, in more than 200 volumes, contain some 4,239 papers, or an average of some 50 papers per annum, not more than half of which can be read and discussed. It seems to me quite clear that we are therefore not sufficiently in touch with the work of our members, and that the formation of local associations would lead to the presentation to them of many papers of special, personal, or local interest. I know nothing more useful and stimulating than such papers when criticized by local knowledge.

Registration of Engineers.—There is a second problem with which we are faced. Has the time come for some legal status to be sought for the profession of the civil engineer, not only in the interest of the civil engineer, but also of the public at large? The founders of our institution hoped and expected that membership of the institution would become the recognized stamp of the trained civil engineer, and that the public would thereby be protected and enabled to select fully qualified men to undertake the design and construction of public works. It is a curious coincidence that these problems of recognition and registration, which are occupying our attention now, were also under consideration 32 years ago, when efforts were made to obtain an act of parliament for the registration of qualified practitioners in architecture, civil engineering and surveying.

In the year 1886 the Council of the Institution of Civil Engineers appended the following note to their annual report:

"The use of the simple letters 'C. E.' is expressly discountenanced by the institution, as not founded on any qualification and as being calculated to mislead."

Our by-laws enjoin on all classes of members the use of the official designation, M. Inst. C. E., Assoc. M. Inst. C. E., etc.

The architects, engineers, and surveyors' bill referred to was opposed by this institution, and withdrawn by its promoters before its second reading. The grounds of the opposition of the institution are set forth in a statement of the council against the second reading of the Bill. They are to be found on pages 176 to 178 of the 94th volume of the Minutes of Proceedings. This statement formed the basis of the petition to the House of Commons, which was duly presented by Mr. Alfred Giles, M. P., then a vice-president of the institution. A generation has since passed away, and we are again face to face with the same problem. Your council recently decided to test the views of the corporate members of the institution, and submitted the following form of inquiry to those resident in the United Kingdom:

"I ———— approve of the Institution of Civil Engineers taking steps to obtain statutory powers to prescribe the qualifications and to conduct examinations for admission to the profession of civil engineering, to keep a register of civil engineers, and to prevent persons who are not duly qualified from holding themselves out as members of that profession."

Ninety-seven per cent of the replies were in the affirmative. That I view as a distinct direction to seek the necessary powers. It is not claimed or intended that every qualified civil engineer must be a member of this institution, but that no one should claim to be a civil engineer without being suitably and legally qualified. We do, however, desire that membership of this institution shall be an undoubted proof of the highest qualifications.

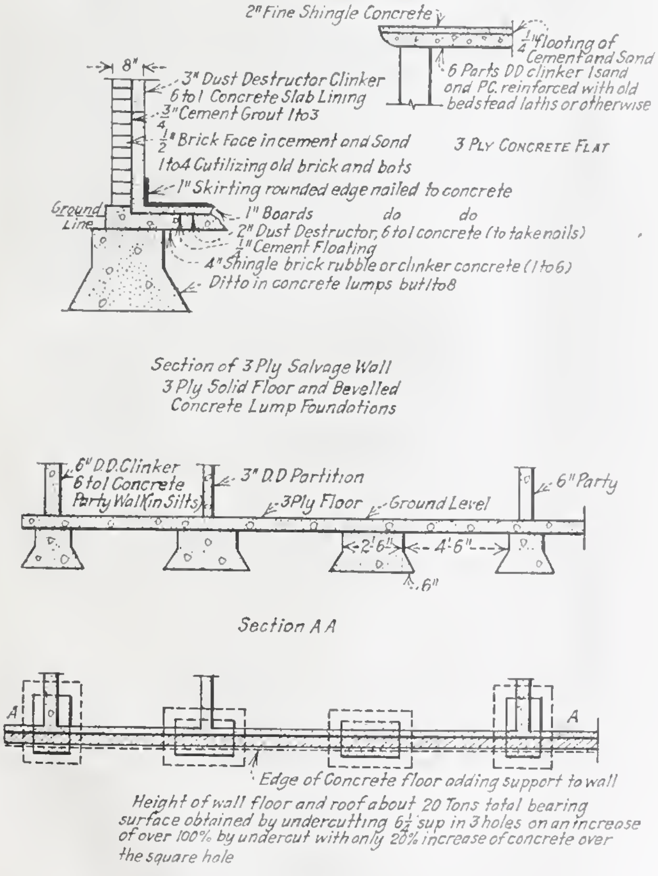
The Three-Ply Building Wall Constructed of Salvage Material

By E. A. SLATER,
Borough Engineer, Newport, Isle of Wight.

From The Surveyor, London, Oct. 17, 1919.

A few months ago, on the request of the Secretary of National Housing, a sample block of three-ply walling was sent by the author to Whitehall for examination by the newly formed Standardization and Construction Committee. This committee have now recommended this construction for national housing, and a copy of the specification appeared in the first number of the journal "Housing," issued by the Housing Department of the Ministry of Health.

The method of construction is explained by the diagram, and it will be seen that in many respects the principle is the same as that suggested by the author in "Structural Economy" (1912), and applied by him to building works ever since about 1902, the chief variation being the substitution of the salvage concrete slab for brickwork for the inside lining. It is based on the idea that the easiest way of applying a water-tight layer of cement is by pouring it in, that the center of the wall is the best position for such a layer, for convenience, for protection from sun, atmosphere and damage by blows, for watertightness, being forced by liquid pressure between two unyielding surfaces, and in that position it gives great longitudinal strength, justifying the adoption of the concrete lump foundation (as explained in sketch); also that it binds the two thicknesses of wall together so effectively that it is impossible for any part to be separated without fracture (as proved by broken sample), and finally that cement is used for this layer, as in the whole construction of wall, because it is the only known material giving the necessary strength and waterproofing that at the same time improves with age. The substitution of breeze concrete, or preferably, dust destructor concrete for inside lining in place of 4½-in. brickwork, is a later development.


2" Fine Shingle Concrete
¼" flooting of Cement and Sand
6 Parts DD clinker 1 sand and P.C. reinforced with old bedstead laths or otherwise
3 Ply Concrete Flat
8"
3" Dust Destructor Clinker 6 to 1 Concrete Slab Lining
¾" Cement Grout 1 to 3
½" Brick Face in cement and Sand 1 to 4 Cutilizing old brick and bats
1" Skirting rounded edge nailed to concrete
Ground Line
1" Boards do do
2" Dust Destructor, 6 to 1 concrete (to take nails)
¼" Cement Floating
4" Shingle brick rubble or clinker concrete (1 to 6)
Ditto in concrete lumps but 1 to 8
Section of 3 Ply Salvage Wall
3 Ply Solid Floor and Bevelled
Concrete Lump Foundations
6" D.D. Clinker 6 to 1 Concrete Party Wall (in Silts)
3" D.D Partition
3 Ply Floor
Ground Level
6" Party
2'6"
4'6"
6"
Section A A
A
A
Edge of Concrete floor adding support to wall
Height of wall floor and roof about 20 Tons total bearing surface obtained by undercutting 6¼"s up in 3 holes on an increase of over 100% by undercut with only 20% increase of concrete over the square hole

Sketch Showing Application to Front Wall of Cottage.

Advantages Claimed.—The advantages can be summarized as follows. Economy.—As the binding material (cement and sand) is stronger than the brick itself, what may be called salvage material may be used. Second-hand, broken bricks, pieces picked out from brick rubble heaps arising from the demolition of condemned and derelict buildings can be substituted for costly new bricks, for the face. As an example, I have recently bought for £12 an old ruined brick kiln, which will provide sufficient for external walls of about a dozen A class cottages, and an old cottage for £3, sufficient for two more. The dust destructor clinker is more or less a waste product; we often have to pay to cart it away, and I estimate that in my town there are sufficient ruinous buildings to supply brick material for the whole of its housing scheme, so that an immediate start can be made. Instead of about 20,000 whole new bricks for the house in a row, about 4,000 old bricks and bats will suffice, just for the half-brick facing and enclosing chimney stacks (filled in with concrete), bricks, of course, being unnecessary for party walls and internal partitions, for which dust destructor clinker concrete is preferable. Hence expedition as well as economy. The main volume being of low-cost material outweighs the present artificially high cost of cement, and in an analysis made a few months ago the cost worked out at 1s 2d (28 ct.) per square foot, against 1s 10d (44 ct.) for ordinary construction; but probably 25 per cent should now be added to these prices.

Watertightness.—Proved by test of sample submitted to the Standardization and Construction Committee, Whitehall of other samples, and by previous experience.

Ivy and creepers can be trained to grow on wall with impunity.

The inside lining of clinker concrete will take a nail easily and firmly, so that skirtings, picture rails, doors and window frames, etc., can be fixed thereto without grounds, plugs and backings. The internal rough surface forms a good key for plaster, and only a thin coat required. Being, like breeze concrete, of an absorbent nature, and not like shingle concrete, it conforms with the Tudor Walters report as suitable for inside lining of external walls as well as for the whole thickness of party and internal partition walls.

Strength and Endurance.—The author has compared the cost with a hollow wall in lime mortar, pointed in cement, but such a wall would not stand the hard wear of working-class dwellings for 80 years; even the pointing will come away from the effects of weather and mischievous children who delight in raking out joints. A chance blow, or trying to knock a nail in the wrong place, will displace a brick or knock mortar into the cavity. The strength given by the vertical grouted layer is worked out in "Structural Economy," p. 120, from which it can be seen that the wall would safely carry its own weight and weight of floor, etc., over a span of 7 ft. without any foundation, and by adoption of beveled concrete lump foundations, with floor carried over (see sketch), over 50 per cent reduction can be made in the cost of foundations.

Inspection and danger of inferior work escaping notice is reduced, the grouting being itself a hydraulic test of the wall. With ordinary bonding each course should be inspected before buried by the next to ensure that spaces are properly filled up; but with this wall all that is required is that the grouting should be mixed and applied under supervision, whether at vertical intervals of 2 ft. or more—i. e. one inspection instead of eight. If there are spaces left inside the wall the grout will fill them and the wall be all the stronger.

Non-conducting, will keep out cold and retain heat.

Specification.—External walls of houses to be 8 in. thick, constructed as follows:

Face to be half brick thick of old bricks, three-quarter bricks or bats to show not less than 3½ in. long on face, to be supplied by the corporation, to be laid and jointed in cement and sand (supplied by the corporation) 1 to 4, laid to break joint, face joints neatly weather struck as the work proceeds, joints kept horizontal, not less than ½ in. nor more than ¾ in. thick.

Lining.—Inside lining to be of 3 in. dust destructor clinker concrete, slabs to be supplied by the corporation. Note.—The slabs will be molded by the corporation in widths and lengths to suit lengths of walls and openings and numbered so as to fit with a minimum of cutting, and composed of 6 parts dust destructor clinker crushed by steam roller and screened to pass through all sizes up to ¾-in. gauge, 1 part shore sand and 1 part Portland cement. Slabs to be laid and plumbed and jointed in cement and sand 1 to 4.

Grouting.—The vertical joint between brickwork and concrete to be grouted up in cement and sand grout 1 to 3, made just so thick as to run into joint without clogging. No grouting or mixing of same to be done except under the supervision of the architect or his representative. Note.—Wrought-iron clips or cramps will be supplied by the corporation to clip over top edge of slabs and outside of brickwork to hold same until grouting is set. Although it will be generally convenient to grout in at level of top of each row of slabs, this is not essential; the height up to one story can be carried up and then grouted, provided that care is taken that too great a height of liquid grout is not put in unset at one time so as to force out green work.

In a hospital ward at Colchester this was done. Grouting was left until all brickwork was completed, then grouting done in two operations, the first filled in for greater part and remainder next day, the interval enabling the lower part to set and hold wall and so prevent undue liquid pressure.

Applications of 3-Ply Construction.—The three-ply idea is also applicable to ground-floor construction and to flat roofs for dormers and outhouses. Not that the author would like to see it substituted for tiles for the main building on account of loss of color effect, though cheaper. But for outbuildings at rear, water-closet and coals, which often cannot be conveniently arranged inside, a flat roof is advantageous; the extreme height of roof can be kept down to about 7 ft., little more than the height required to screen off neighbors, without unduly shadowing rooms, and it has been proved that it is dry-rot proof for floors as well as damp-proof, without the aid of tar or asphalt.

Naturally, in applying the principle of actual practice, as the author has been doing lately, in the erection of corporation stables and cart shedding, we pick up as we go along many little points tending to facilitate construction. A convenient height for slabs is 2 ft.; the length of most of the slabs may also be 2 ft. The 2 ft. by 2 ft. slab weighs about 112 lbs., and two men can easily fix two in five minutes, including jointing up ready for grouting; this is working at about four times the sped of ordinary bricklaying. On the other hand, we cannot expect the bricklayer to lay a mixture of bricks and bats (mostly the latter) as quickly as whole bricks—it will take quite half as long again; and a good deal depends on the skill, not only of the bricklayer in finding one good face to show on the outside, but of his attendant in picking out bats for him, with one good face (even if only 3 in. long). The gain in speed in laying the slabs more than balances the loss in time over the bats, while grouting is quicker than rendering, and can be done by the unskilled laborer at odd times. We find that the 2-ft. square slab stands firmly on its bed, even in windy weather, and requires no temporary support while the cement is setting. But the bricklayer should be instructed to carry up his 2-ft. height of brickwork first and the row of slabs after, so that there is no trouble with droppings in the cavity.

For the stables referred to the slabs were brought to a smooth face with the trowel, so that no plaster is required; but probably for cottages a thin coat of plaster would be preferred.

Stainless Steel for the Engineer.—Sheffield, which taught the world how to make steel, is actively engaged in developing the engineering applications of that wonderful iron alloy known as "stainless steel." The most obvious use for this material was in connection with cutlery; and that was practically the only line exploited before the war. Now there is a prospect that stainless knives will be only one among a host of more imposing uses of a metal unaffected by atmospheric moisture and many acids. During the war it has been used for the valves of aero engines and the blades of steam turbines both of which demand a substance with great resistance to erosion. Valves and rods for pumps offer another wide field, and the advantages of a rustless steel for marine purposes need not be emphasized. In the electrical field, it has been found adaptable for permanent magnets and ideal for electric cooking and heating apparatus, the efficiency of which depends largely upon the brightness which prevents the waste of heat by radiation. Surgical instruments are also being produced in stainless steel, making cleanliness a simple matter and obviating the necessity of plating even under the worst conditions.—Indian and Eastern Engineer, October, 1919.

Relative Advantages of Single and Double-Coat Bituminous Road Surfacing

By FRANCIS WOOD.
Borough Engineer and Surveyor, Blackpool.

Abstract of a paper read Nov. 24 at the Road and Transport Congress of the County Councils Association.

Some years ago, whenever a macadam road in the district under the control of the writer cost about 1s. per square yard per annum, it became a rule that that road should be wood paved, because during the period of the life of such a pavement, the cost would be lower than 1s per square yard per annum. Twelve miles of wood-paved roads in Fulham cost about 6d per square yard per annum, and the heaviest trafficked part of the Fulham road cost about 9d per square yard per annum. Since then, bituminous structures have been found to be much cheaper in first cost and to have a life of at least 15 years; thus a modification was made to the rule, so that wherever a macadam road was costing more than 4d per square yard per annum, this form of structure was substituted; it gave not only a better surface requiring less attention and a far longer life, but it was over its life not more costly to maintain.

The bituminous structure is one that is known as the two-course pavement, i. e., a base coat and a wearing surface coat. The base coat has been simplified and made as cheap as possible by using broken hard stone, of any kind, from granite, clinker, York stone, limestone, bricks, etc., or from the old material scarified out of the road itself, the size being from 2 in. to dust, 60 per cent of the mixture being of the larger material. It is mixed with a composition of tar, pitch and bitumen, which gives a penetration of 120 at 60° F. on a Bowen penetrometer. The materials is heated to about 400° F. and the previously-mentioned bituminous mixture is added when the material is under 300° F., thoroughly mixed in a mechanical mixer and taken to the prepared road, and laid while still hot to a depth of 3 in. This base coat, as soon as it is cold, is so tenacious that a lorry with a load of 10 tons can come on to it and make but the slightest impression of its track. The surface of this base coat has an open appearance, such as will give a good key for the material that is to be laid on the resulting surface as a wearing coat.

This wearing surface coat is composed of a graded aggregate of mineral particles such as sand, granite dust, cement and bitumen, the grading being: 40 per cent passing through 200, 100 and 80 meshes (one-third passing the 200 mesh), 40 per cent passing through 50 and 30, and 20 per cent being of the 20 and 10 mesh and bitumen—the latter is about 12 per cent.

A few years ago the writer was impressed with the idea that a single-course pavement would prove to be one that would give satisfaction, and a number of experiments were made which seemed to amply justify that conclusion, with the result that several miles of roads were laid, the composition being almost precisely the same as is found in an ordinary macadam road, but bitumen was used as a substitute for moisture. The whole of the material was mixed, as described above, in a mixer, so that the bitumen (about 8 per cent by weight) entirely covered the stone and other particles. After about the fourth or fifth year, under heavy traffic, the structure gave signs of surface disintegration. The writer's impression of the causes is, that the bitumen expands and contracts under atmospheric temperatures to an extent which is unequal where large stone is in the surface and must come in places to the surface but extending downwards to a depth of 1½ in. to 2 in.; that there is, therefore, a liability to leave infinitesimal fissures into which moisture, such as dew, etc., enters and prevents readhesion; this would, in the end, be sufficient to cause the effect mentioned. He came to the conclusion that, where a material is to be laid and which is to act as a wearing surface, the aggregate in the composition should in no case be larger than ¼ in. Such a composition would not necessarily be stable under heavy loads, and it therefore becomes necessary to divide it into two parts or coatings, the lower or base coat to act as a support and foundation for the upper or wearing surface coat, which is composed entirely of small-sized particles and bitumen. This method has proved very satisfactory and as cheap as the single-coat structure.

A coating of tar, on the finished surface of a tar-macadam road, is invariably necessary to complete its effectiveness. Unfortunately, such a coating of tar scarcely lasts beyond 12 months, and if this coating is not repeated, the wear or deterioration is rapid. If the cost of this annual coating is capitalized, and the resulting amount expended on a wearing surface coat about an inch in depth, the tar painting, which is an annual annoyance to traffic is dispensed with, and a better and more lasting surface is gained.

The writer has made for light trafficked roads a one-course pavement which may be said to be intermediate between compressed or artifically-made asphalt and mastic asphalt, i. e., it is not so rich in bitumen as latter but more so than the former; it can be laid more quickly and effectively as compared with mastic asphalt; and it satisfies medium trafficked roads where the expense of a two-course pavement may be a serious item.

Assuming the mixture of tar, etc., for the base to cost 1s per gallon, and that 10 gal. is used per ton of material, then the cost of the mixture is 10s, to which labor costs 4s 6d per ton, making the total cost of the base 14s 6d per ton; add 3s 3d per ton carting each way, the cost on the job is 21s, at 7 yards per ton equals 3s per square yard. The surface wearing coat is about 90s per ton at present prices, which are exceedingly high, and it is hoped will soon come to a more reasonable figure. This equals 4s 6d per square yard. Allowing 2s 6d per square yard preparing the surface, etc., the total cost is 10s per square yard.

Concrete Chuting Plant at Clyde

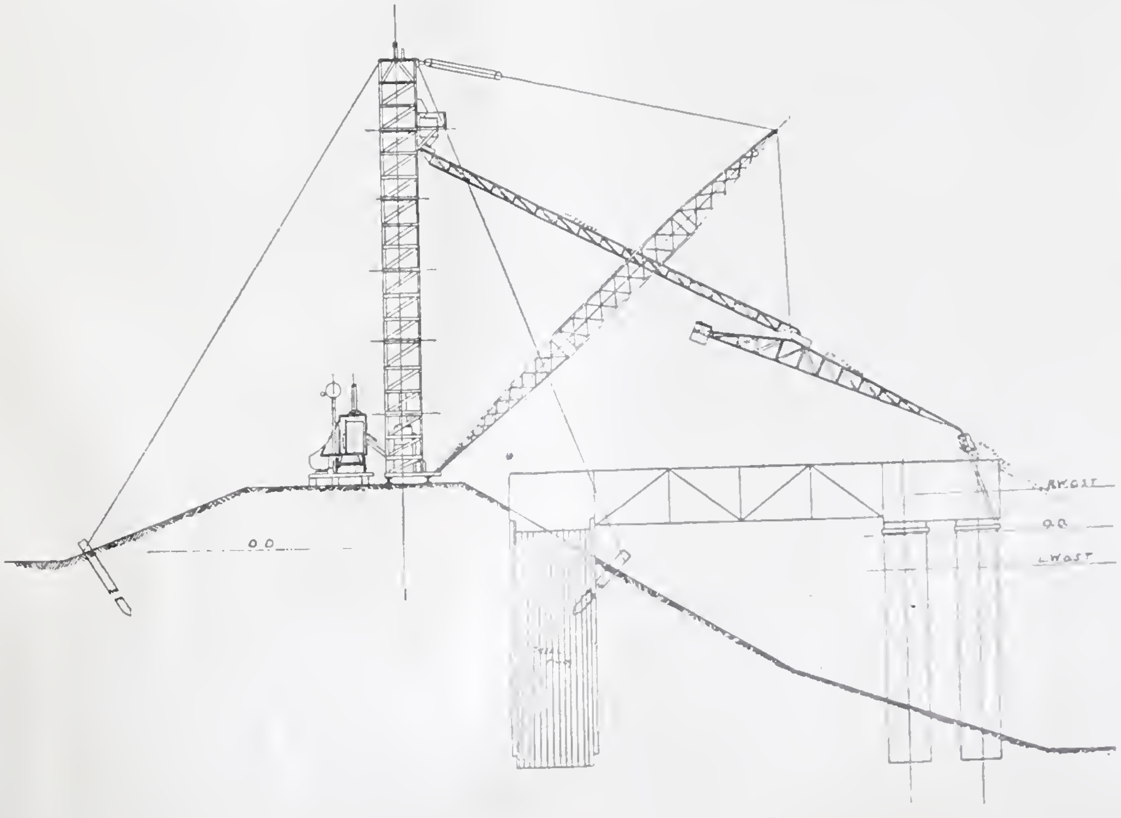
From Concrete and Constructional Engineering, London, November, 1919.

The use of troughs arranged for placing concrete over a considerable area, although common in the United States of America and Canada, has not apparently been adopted in this country until recently, when the admiralty scheme for pumping oil fuel across Scotland from the Clyde to the Forth was being carried out.

At the Clyde end of the pipe line a double row of columns had to be built in the river to carry landing stages for the tank steamers, these columns consisting of steel plate cylinders filled with concrete. When the question of filling the cylinders and placing the concrete for the flooring of the stages was under discussion, it was suggested that the most expeditious method, and the one most economical in man power, would be for the concrete to be mixed on the shore and conveyed to the cylinders and stages by troughs. This proposal was adopted by the admiralty engineer, and the work was entrusted by Messrs. Morrison & Co., Ltd., the contractors for the Clyde oil fuel installation, to the British Steel Piling Co., who had supplied the sheet piling and pile driving plant for the river embankment at this depot.

The plant consists of a concrete mixer with side loader, from which the mixed concrete falls into a skip at the bottom of a steel tower 72 ft. high. The skip is lifted to the top of the tower by a steam winch, and when at the top is automatically discharged into a hopper fixed on the outside of the tower. From a gate at the bottom of this hopper the concrete is discharged into the first trough, the gate being arranged to be operated from a platform around the hopper or from the ground. The first trough, which is 72 ft. long, is carried by a lattice girder and discharges into a second trough 32 ft. long, this trough being carried on a girder provided with a balance box to afford means of easily fixing the girder and trough at any angle required for the work. From the end of the second trough a third trough 24 ft. long is suspended by a universal joint following the trough to swing a complete circle horizontally, and also providing all the necessary movement in a vertical plant to suit any angle at which the trough may require to be used. A similar universal joint is provided at the junction of the first and second troughs. The weight of the troughs and their contents is carried by a steel lattice jib, 80 ft. centers pivoted to the base of the tower and provided with wire rope luffing tackle, the luffing gear being worked from the winch. The jib is designed to slew through an angle of 90° and the troughs are suspended from the jib by wire rope blocks, which provide for raising and lowering the troughs as required. The maximum radius of the plant is 112 ft. Traveling wheels are provided to enable the tower to be moved into another position when required.

The whole of the plant was designed by the British Steel Piling Co. of Dock House, Billiter St., London, and the manufacture was carried out at their Greenwich works, where they have just completed another plant in which the tower is 104 ft. high and the radius reached by the troughs 140 ft., this plant being designed to place the concrete for a large 17-story building in the Glasgow district.



General Arrangement of Concrete Chuting Plant.

The Economical Design of Wooden Water Conduits for Power Developments

By CAPT. W. T. TAYLOR.

From The Engineer, London, Sept. 26, 1919.

Every engineer who has had any experience with the wooden conduit knows the interruptions of service caused by it. Unquestionably it is the weakest link in power transmission for the reason that, from a financial standpoint, it cannot be built in duplicate. It is short lived—about 15 to 20 years—but several can be built for the cost of a tunnel, and, for those remote countries the author has in mind and where only a limited amount of money is available, due regard for the first principle of engineering is paramount, namely, economy. At all times where a tunnel can be made to replace an open conduit it should be used. Its first cost would be greater, but, mile for mile, from the standpoint of costs of maintenance, depreciation, interest, etc., it will be almost as cheap and far more reliable, and in many cases one mile of tunnel will replace several miles of open conduit, and the advantages of the tunnel are much greater. The best engineering solution at all times is to build every part of a hydo-electric plant in the most substantial manner possible, and construct the conduit of the maximum possible capacity in order that the water power may be utilized at a load factor of 100 per cent or as near it as possible.

It is true that a wooden conduit costs only about 50 per cent as much to build as a concrete conduit,* but if the depreciation, maintenance and interest on the investment are taken into consideration the cost of both will be about the same when carried over a few years. The cost for a tunnel as against a wooden conduit may be four times as great for the same capacity flow. However, the comparison must depend upon how much of a short cut it makes; an open conduit must follow the contour of the hillside, whereas a tunnel cuts through the hills. In general, it cannot be said that wooden conduits, simply equipped powerhouses, wooden poles and simple substations are always wrong, and that concrete conduits, elaborately equipped powerhouses, steel towers and elaborate substations are right. Very often we do not build more permanently for the very simple reason that money is not available. In designing it is always well to bear in mind the country and that the ultimate development of the art and of the country has not yet been reached. Sometimes the engineer is called upon to make installations on the assumption that the plant is to be abandoned after a few years' operation. He will be criticized if he puts in a plant to meet present or apparent future needs and, owing to some change in the industry or development of the country, the plant has to be remodeled later. It is not so difficult to determine the proper power plant to build when unlimited capital and good power conditions exist as when there is restricted capital, limited revenue and low-priced power near the consumer. In taking up the question of the wooden conduit the writer desires to emphasize the fact that its use is almost entirely restricted to certain defined parts of the world where money is dear, and that tests and experiments on this design of conduit were made, giving the kilowatt loss per unit length of conduit due to the grade and showing how closely they were related to values giving the most economical conductor, i. e., Kelvin's law for the most economical conductor.

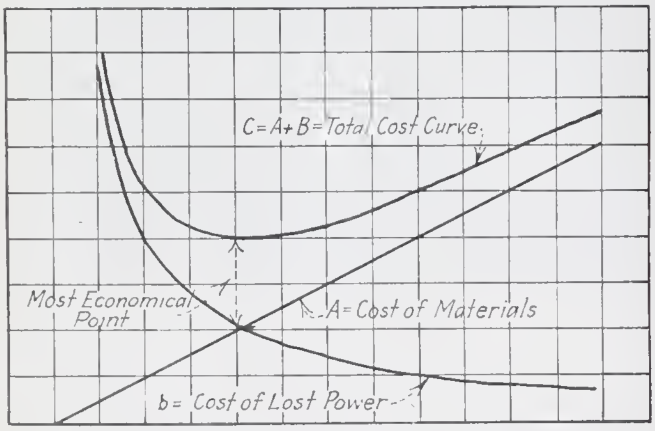


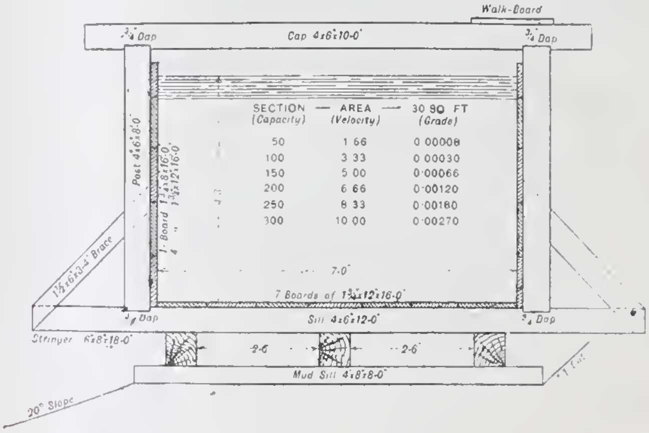
Fig. 1—Kelvin's Law for Most Economical Conductor.

In the selection of a value for the coefficient of roughness great care is needed. For general conditions of well-constructed wooden conduits the following formula can be taken as sufficiently reliable to meet practical requirement:

$$V = C R^{0.7} S^{0.5}$$

where the value of C is taken at 100 for simplicity. The Kutter formula has the advantage of established usage, and the exponential formula perhaps has the advantage of simplicity. However, for all the formulae now generally accepted the agreement is within the probable error in the prediction as to the actual nature of the wetted perimeter or the selection of the empirical coefficient.

In solving problems it is necessary for the engineer, when he has a great many to handle, to be able to give quick and practical solutions. The problem presented here relates to the most economical size of water conduit for hydro-electric purposes. Not unlike the law stated by Lord Kelvin in 1881, it is shown that the most economical area of conduit is that for which the annual cost of energy wasted is equal to or nearly equal to the annual interest on the investment. In other words, for a given capacity in second-feet flow with the price per kilowatt per year fixed and the price of materials fixed, the most economical area of conduit is found by comparing the difference in kilowatt loss with the difference in yearly cost—the minimum difference gives the most economical conduit to install. A graphical representation of Kelvin's law is shown in Figure 1. This law for the most economical conductor has been stated in many ways and is repeated merely as a comparative note on the subject of the most economical water conduit. It shows the relative cost of losses to the relative investment in conductor material; that is, the ratio of fixed charges to the cost of losses in the line.



SECTION (Capacity)	AREA (Velocity)	30 SQ FT (Grade)
50	1 66	0 00008
100	3 33	0 00030
150	5 00	0·00066
200	6 66	0·00120
250	8 33	0·00180
300	10 00	0·00270

Fig. 2—Section of Wooden Conduit.

TABLE I—SHOWING QUANTITIES PER LINEAL FOOT.

Section area (sq. ft.).	Dimensions (feet).	Hydr. radius.	Lumber (ft. B.M. per ft.).	Nails (lb. per ft.).	Excavating and levelling (cu. yds. per ft.).
10	2.5 × 4.0	1.112	27.0	1.2	0.17
20	3.5 × 5.75	1.568	46.9	1.43	0.39
30	4.3 × 7.0	1.924	67.0	2.55	0.68
40	5.0 × 8.0	2.222	77.8	2.58	0.87
50	5.6 × 9.0	2.486	95.2	2.95	1.07
60	6.0 ×10.0	2.730	108.7	3.25	1.29
70	6.36×11.0	2.953	133.5	3.47	1.52
80	6.9 ×11.57	3.130	146.5	3.74	1.80
90	7.2 ×12.5	3.345	157.5	3.85	2.08
100	8.0 ×13.0	3.352	182.0	4.0	2.38

(For design of the 30 sq. ft. conduit see Fig. 2.)

The operating manager is directly interested in the value of the energy lost per year in transmitting water power and electrical energy and in the interest cost of these two very important parts of the system. Electrical transmission line economics from this standpoint has received a big share of attention, but very little has been done and little knowledge has been published to simplify present-day problems seeking for the highest efficiency of water conduits. A conduit given its grade and constructed can only be changed at a very great expense. The character of the ground will place certain limits on the velocity so that the grade chosen will depend on the condition of the ground. The grade necessary to maintain the velocity within the desired limit will also depend on the interior surface of the conduit. The form and area also affect the grade, because they affect the velocity. The conduits under reference and shown in the curves in Figure 3 are in the ratio of approximately 6:10 for the waterway. The coefficient of roughness n = 0.013. Table 1 gives technical particulars and the quantity values per lineal foot of conduit for the designs shown in Figure 2.

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*This depends on the geographical situation, local conditions for timber growth, and the country itself.

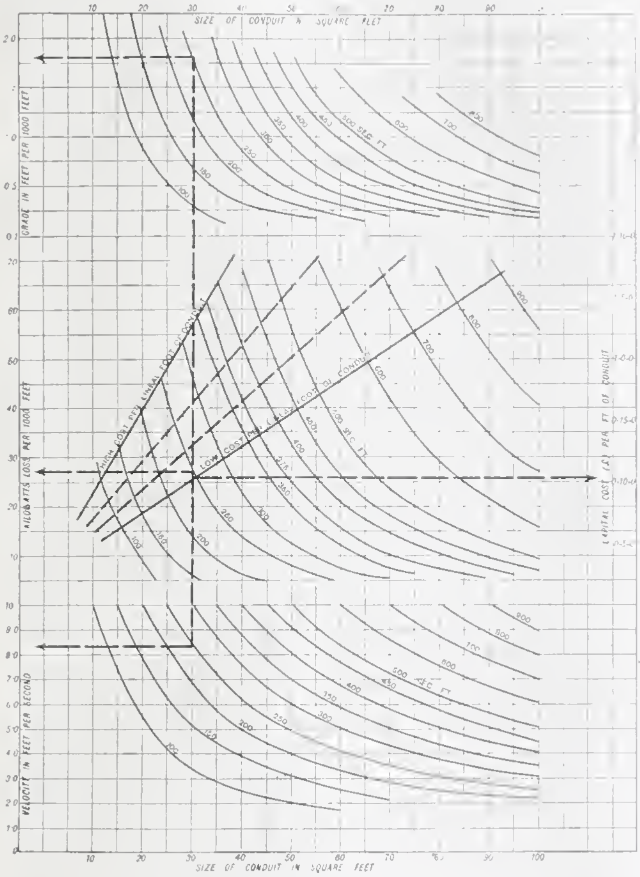

Fig. 3—Curves for Design of Conduits.

The materials cost curve—capital charges—may be made up in various ways just as the engineer considers the best and as local conditions warrant. The cost may be plotted and adjusted to the curves "kilowatt loss due to grade." The sum total of these two different sets of curves resembling "A + B = total cost," shown in Figure 1 for Kelvin's law, can be drawn, and shows at once the most economical conduit to put in.

Table II—Conduit Area, Velocity, Grade and Kw. Loss in Terms of Water Flow in Second Feet Per 1,000 Lin. Ft. of Conduit.

Conduit section, sq. ft.	Factors involved	Capacity flow in second feet													
		50.	100	150	200	250	300	350.	400	450	500	600	700	800	900.
10	Velocity Grade Kilowatts	5.00 1.26 4.06	10.00 5.40 32.40												
20	Velocity Grade Kilowatts	2.50 0.22 0.66	5.00 0.88 5.28	7.50 1.90 17.12	10.00 3.60 43.20	12.50 5.20 78.00									
30	Velocity Grade Kilowatts	1.66 0.08 0.24	3.33 0.30 1.80	5.00 0.60 5.94	6.66 1.20 13.44	8.33 1.80 27.00	10.00 2.70 48.60								
40	Velocity Grade Kilowatts		2.50 0.14 0.84	3.75 0.31 2.70	5.00 0.55 6.60	6.25 0.86 12.90	7.50 1.25 22.50	8.75 1.70 35.70	10.00 2.20 52.80						
50	Velocity Grade Kilowatts		2.00 0.08 0.48	3.00 0.18 1.62	4.00 0.31 3.72	5.00 0.47 7.05	6.00 0.69 12.42	7.00 0.91 19.60	8.00 1.20 28.00	9.00 1.53 41.30	10.00 1.90 57.00				
60	Velocity Grade Kilowatts		1.66 0.05 0.30	2.50 0.11 0.99	3.33 0.19 2.28	4.16 0.29 4.34	5.00 0.42 7.56	5.83 0.57 11.96	6.66 0.75 18.00	7.50 0.95 25.65	8.33 1.20 36.00	10.00 1.67 60.00			
70	Velocity Grade Kilowatts			2.14 0.07 0.63	2.86 0.13 1.56	3.57 0.20 3.00	4.28 0.28 5.04	5.00 0.38 7.98	5.71 0.50 12.00	6.42 0.63 17.00	7.12 0.77 23.11	8.56 1.15 41.40	[illegible] [illegible] [illegible]		
80	Velocity Grade Kilowatts			1.88 0.45 0.40	2.50 0.09 1.08	3.12 0.14 2.10	3.75 0.20 3.60	4.37 0.27 5.66	5.00 0.36 8.64	5.62 0.45 12.32	6.25 0.55 [illegible]	7.50 0.80 [illegible]	[illegible] [illegible] [illegible]	10.00 1.45 [illegible]	
90	Velocity Grade Kilowatts				2.22 0.07 0.84	2.78 0.10 1.60	3.33 0.14 2.61	3.89 [illegible] 4.20	4.44 [illegible] 6.24	5.00 0.37 8.92	5.55 0.41 12.32	6.66 0.58 20.90	[illegible] [illegible] [illegible]	8.88 [illegible] [illegible]	10.00 [illegible] [illegible]
100	Velocity Grade Kilowatts				2.00 0.05 0.60	2.50 0.08 1.20	3.00 0.11 1.98	3.50 0.15 3.15	4.00 0.19 4.28	4.50 0.25 [illegible]	5.00 0.31 9.30	6.00 0.44 18.43	7.00 0.64 26.80	8.00 0.84 [illegible]	[illegible] [illegible] 83.40

The water conduit of each power plant is a distinct problem to be solved in accordance with the particular requirements and the means at hand. The nearer developments of this kind are to industrial centers the better—and more expensive—conduit one can afford to put in. When timber is abundant the timber conduit has been used successfully and will be used in future, for while it has a comparatively short life it is very often the means of reducing the first cost to a minimum. Conduits of concrete have been used in a few cases, but the cost has barred the way to their being used more extensively. It is generally agreed that as hydro-electric work becomes more permanent in character the use of timber for water conduit construction becomes less.

Referring to the curves, Figure 3, an example is shown covering the design given in Figure 2, which shows at a glance that for a given total cost of materials in place the most economical area for a conduit capacity of 250 second-feet is 30 sq. ft. By following the line of 30 sq. ft. value up and down from the center set of curves—kilowatt loss due to grade—to where the line intersects curves for 250 second feet the values for grade in feet per 1,000 and velocity in feet per second respectively can immediately be obtained. These values were obtained by experiments and tests, and it is hoped they will be the means of starting investigations and tests along the same lines involving the factors shown in Table II on other types of conduits used for hydro-electric purposes.

A New Source of Energy

In his address at the James Watt centenary, Sir Oliver Lodge discussed a possible source of energy highly desirable from the standpoint of thermodynamics, but as yet unavailable to the engineer. In his discourse he drew attention to the fact that the discovery of radio-activity had proved, as was already believed from theoretical considerations, that an immense amount of energy was locked up in the atoms, but that this energy was at present inaccessible. He saw, however, no reason why this condition of affairs should continue. This store of energy resulted, he said, from the very structure of the atoms and was enormous in quantity. If it could be utilized on any extensive scale the whole conditions of factory life would be ameliorated. There would be no smoke from imperfectly burnt fuel, or dirt from the transport of coal and ashes. The power would be most compact and very clean. Indeed, its very concentration might lead to occasional explosions due to the energy being liberated more rapidly than intended. Nevertheless this drawback notwithstanding, the conditions of utilization would, no doubt, be good on the whole, and possibly some one standing 100 years hence where the speaker stood now would be able to tell how the feat of developing this source of energy had been accomplished. For the present, however, we were merely at the beginning of the utilization of atomic energy.

As instancing the amount and degree of concentration of this energy, Sir Oliver said that the disintegration of one grain of radium gave out sufficient energy to raise the temperature of one ton of water from the freezing point to the boiling point. In fact, the energy set free by the disintegration of radium was a million times as great as that generated by the combustion of an equal weight of hydrogen. On the other hand, the combustion of hydrogen, could be controlled, whilst the break-up of radium was extremely slow and not under control. What happened was that every now and then some individual atom of a mass of radium, shot off an α particle. Other α particles were shot off in succeeding transformations, the final residue being common lead. There were radio-active substances still more energetic than radium, but as a necessary consequence they were correspondingly more rare. Of 3,000 atoms of radium, one on the average got each year into an unstable condition and fired itself off, so that radium had a relatively long life. The number of atoms in even a milligramme (about 1/70 grain) was, however, extremely large, so that a milligramme of radium fired off nearly 30 million shots per second. These shots moved at a prodigious velocity, equal to about one-fifteenth that of light, and their energy was accordingly enormous. At present this energy was inaccessible. In fact, each atom of every metal had a vast store of energy locked up in it, but most of them were quiet about it, whilst the radio-active elements liberated this energy spontaneously without external stimulus.

Could a stimulus be found a first step would be made towards the utilization of the energy in the atoms; and if ultimately we were able to utilize the whole of it, we would be able to find sufficient in an ounce of matter to raise the whole German fleet and pile it on top of a Scotch mountain. To repeat, in each ounce of a metal there were locked up millions of foot tons of energy, at present quite inaccessible. Perhaps it was a good thing that the stimulus required to release this energy had not yet been discovered. It would place enormous powers for evil in the hands of such an uncivilized nation as we had had to live with during the past five years, and it would be well that the human race should advance further in morals and brains before the momentous discovery was made. If the power got into the wrong hands the very planet might be unsafe, since a liberation of the atomic energy on a large scale would be sufficient to blow it up.

Reinforced Concrete Quay Walls in Dutch Indies

From De Ingenieur.

At the Port of Soerbaja in Java the depth of the channel increased from 14 ft. in 1907 to 21 ft. in 1918. At high tide the water rises 6 ft. and vessels with a draught of 21 ft. can enter or leave at any time. A depth of 28 ft. below sea level occurs over an area of 333 sq. yd. in the least favorable part of the port. In 1911 a Dutch firm undertook to execute the requisite harbor work for $5,700,000, including the construction of a flat area 220 yd. wide on the west of the Kali Mas, and restricted on three sides by sunken walls (built on caissons) at a depth of 44 ft. below sea level, and rising to 3 ft. below the surface. The caissons were similar to those used at Rotterdam, and were 40 ft. high by 130 ft. by 40 ft., each being divided into 30 chambers. The bottom is 10 in. thick and the sides 8 in. The concrete consisted of Portland cement and sand and stone in the proportion of 2:3:4, the chambers nearest the water being filled with a mixture of 1½ parts of Portland cement, ½ part of trass, 3 parts of sand, and 5 parts of crushed stone. The other chambers were filled with sand. The superstructure consisted of a concrete wall 5 ft. thick, of cement and sand and stone, in the proportion of 1:2:4. No special incidents were reported during the progress of the work, but the western portion fell suddenly into the entrance to the port on May 3, 1916, without giving any warning except a few cracks in the adjacent ground.

No lives were lost, but three caissons and their superstructure slipped forward and fell, so that the top of the caissons was immersed in the water. It has since been found that the bed of sand on which they were built was contaminated with a stratum of ferruginous mud about 3 ft. thick, which was loosened gradually by the water and so was the cause of the accident. The quay was repaired by constructing three shields of reinforced concrete surrounding the caissons, removing the superstructure from the latter by blasting, withdrawing the sand by suction and raising the caissons to their former position. All three caissons were restored within nine months after the accident and stronger foundations provided at a cost of $132,000.

An extension of the coal quay on the southern side of the same harbor was effected by means of a series of caissons 43 ft. wide, with a mass of sacks filled with cement placed so as to form a buttress 30 ft. wide at the base on the land side of each caisson. The wall thus produced cost $111 per sq. yd.

At the Port of Pirogues in Semarang a series of movements in the quay structure observed in 1913 also showed the necessity of preparing the foundations with sufficient care. The reinforced concrete caissons used at this port were built on a bed 42 ft. wide at a depth of 20 ft. below sea level, the work being commenced in January, 1913. The preparation of the bed was regarded as satisfactory, but movements were observed during the filling with sand. This work was continued until midday of March 10th, 1914, when four caissons began to slip, a strip of sand 4 ft. wide sank to a depth of 5 ft., and cracks up to 73 ft. long appeared in the ground at the rear, the depth of the port being reduced by 5 ft. The movement ceased the next day, and the damage was repaired by erecting two walls of stonework, one in front of the foot and the other behind the base of the caissons, together with an embankment behind the quay wall. A further subsidence occurred in November, 1915, and it was then decided that another mode of construction was essential. This consisted in preparing a much larger foundation of sand, but this did not prove sufficiently stable, and a third attempt was made in which large pieces of coral rock were placed on the sand bed so as to keep it in position. So far this appears to be successful for present requirements, but it would not be safe to use this quay for excessively heavy loads, and there is always some uncertainty as to its safety.

The caissons at the Port of Macassar in Celebes have been protected by a mass of rocks placed on the land side, but even here a slipping of about 1 ft. occurred and several minor movements have been observed. Such a mass of rocks is usually preferable to sand on an uncertain foundation as it has less specific gravity and a high coefficient of friction which greatly reduce the tendency to slip horizontally.

In none of these works has the effect of the seawater on the concrete been appreciable.

Age-Long Engineering Works of China

By PROFESSOR MIDDLETON SMITH.

From The Engineer, London.

An engineer who travels in China, while not altogether disregarding the delights, or the discomforts, of native cookery, naturally is much more interested in the works of construction in the country. There are many and excellent examples of modern engineering science to be seen in that land which defies age, and time, and progress, and the impact of Western civilization. The great dockyards of Hongkong; the railway to Peking; the Kailan Mining Administration; the Hanyang ironworks; and even the hydroelectric plant and high-tension transmission of inland Yunnan, can be quoted as examples.

There seems to be no volume on engineering, past, present, or future, in China. Yet even a feminine author, who traveled a great deal over China, once casually noted that "China is pre-eminently the land of bridges." There is also the Chinese saying of what three great dynasties accomplished while they ruled over the Far Eastern Kingdom. "The Sungs made the roads and the bridges, the Tangs the towers, the Mings the pagodas." It required some knowledge of constructural engineering to do those things.

There are four remarkable relics of ancient engineering genius to be seen in China. They are (1) the works of those old hydraulic engineers, chief of which is the Grand Canal; (2) the works of the wall-builders, which include the famous Great Wall and the less well-known sea-wall, of more than 120 miles in length, along the north bank of the Tsientang River; (3) the works of the people, who must have understood "the theory of structures," and who built the bridges and the pagodas; and (4) the famous clepsydra, or water-clock of Canton.

There is no country in the world in which so much hydraulic engineering work has been done as in China. There are innumerable small power plants—almost all of them "undershot" water wheels, which operate rice-milling plants—and, in comparison with modern plants, very inefficient. All over the country, and especially in the central coastal plains, there is an intricate arrangement of irrigation works and navigation canals. In the dawn of China's history, a ruler, the great Yu, obtained the throne because of his engineering ability, and no doubt he inspired, if he did not actually design, the earliest hydraulic engineering work in China It is probable that the reason why the ancient Chinese practiced as hydraulic engineers was that elementary incentive —the desire for food. Rice is the "staff of life" in China, and rice needs running water in which to flourish. The culture of rice is the most perfect industry in China; but even that can be improved by the application of modern principles of agricultural and engineering science.

The Chinese were probably the earliest canal builders, although the country is blessed by the natural provision of water communication. The records tell us that a canal to improve communication between the West River Valley and the Yangtze was commenced 200 years before Christ. As for the famous Grand Canal, it is usually accepted that the works were begun in the 6th century before Christ, and completed 1,900 years later. Despite the centuries of neglect since the days of the great Kublai Khan (1280 A. D.), the canal survives, and over portions of it steam launches and motor boats travel. The Government of China recently made a contract with a firm of engineers in the U. S. A. for the dredging and repairing of this wonderful old waterway. Probably, in a few years it will be again one of the chief trade routes of the country, supplementing the railways which now run parallel to it almost the whole of its length. It is still a most important means of transport for a thousand miles in length.

The extraordinary thing is that the Chinese brain, in all its thousands of years of attention to canal problems, never devised a canal lock. One must change to a new boat at each section where the level changes.

A portion of the banks of the Canal are elaborately faced with stone. From early days the Chinese protected their cities and their country by walls; and to this day practically all of the large towns are enclosed by walls. Of the Great Wall, General Wilson said that, although it was "laid out in total defiance of the rules of military engineering, yet the walls are so solid and inaccessible, and the gates so well arranged and defended, that it would puzzle a modern army with a first-class siege train to get through it, if any effort were made for its defence." The words were, of course, said before we had the experience of modern artillery in the great war.

An old original wall was built in B. C. 215, but the Great Wall is a modern affair of the 7th century, splendidly rebuilt by the Mings in the 15th century. This greatest piece of masonry in the world, the one artificial constructional work of man on the face of the earth that may be seen by the inhabitants of Mars, kept back the waves of nomadic horsemen from the oldest nation.

A word must be said about the Great Bore of Hangchow. This extraordinary phenomena has been described by Commodore Moore—the Institution of Civil Engineers, 1893—but it is not well known. The writer was three years in the Far East before he heard of it. Yet it is the most wonderful sport the moon has with the earth. A 10-ft. wall of foam rushes up the channel; an awful tide from the ocean. The triumphant moon thrashes the Pacific into this furious outburst, which, with an incredible and awe-inspring roar, dashes against the face of the long sea-wall. The Great Bore, the White Thing, rushes up the narrowing river at a speed of about 12 miles an hour. No vessel can meet that irresistible wall of water and live; a long sea-wall protects the adjacent country.

The wonderful bridges and pagodas, built more than a thousand years ago, cannot fail to interest the engineer. Humpbacked, spectacled, needle's-eye bridges, their arches springing 40 to 50 ft. in the air, with weird and wonderful carvings on parapets and piers, the mellowing influence of time has given them that aspect which age alone can bestow.

Ancient China was the land of the civil engineer; there are few relics of any mechanical ability, unless it be the clumsy cogs and the water-wheels used for rice-milling. Labor was always so cheap and plentiful that mechanism was not needed. Yet the water-clock of Canton deserves mention, if only for its simplicity. There are three big earthen jars on successive shelves, and a fourth, or lowest one, completes the arrangement. The water drops slowly from one jar to the other; a brass scale on the lowest crock tells the hour as it rises. And every afternoon at 5 of the clock, since 1321 A. D., the lowest jar has been emptied, the upper one filled; and thus the clock has been wound up for 24 hours. The city may know the time, for the number of the hour is displayed on boards on the outside wall. To-day the water-clock—drop, drop, drop, it goes—works on as it has worked for 6 centuries. But in the City of Canton, the home of a million yellow people, the city without a beast of burden, and until quite recently without a wheeled vehicle, there now echoes the tick, tick, tick of thousands of time mechanisms made in Britain, America and Japan. But it would be a catastrophe if, in the periodic revolutions of the insurgent city of South China, the water-clock was forgotten or damaged. It is so typically Chinese. It is simple, cheap, and it only requires human labor and patience to ensure that it works properly.

Trade Unionists and Work

From Engineering, London, Nov. 21, 1919, abstract of address by W. Price Abell, M. Inst. C. E., as chairman of the Derbyshire Society of Engineers, delivered Nov. 1.

The prime necessity, unless we are cowardly and blindly optimistic is to face the facts and believe in the call to work. Our adverse trade balance, our sale of securities, our indebtedness to America and the tremendous growth of the National debt cannot be met by paying doles for idleness and decreasing output. The need of houses, furniture and domestic servants shows that the "no work" cry is fallacious. Nor must we forget the half of the population who cannot work—old workmen, old women, children, pensioners and disabled soldiers. The present unrestricted increase of wages spells disaster for such with four millions of trade unionists able to outbid the poor for the scant food and coal, riding roughshod over the rights and needs of the remaining fifty millions of the population—witness the railway strike of Sept. 26. Unless we work and produce goods to exchange for food, the bulk of the people will be in dire necessity. How grossly unfair is the payment to the out-of-work man of three times what is paid to the old age pensioner.

Trade unionism, in spite of the great work it has done, is now guilty of removing disciplinary safeguards of work by the advocacy of a minimum wage and out-of-work pay. Its powers exploited by extremists, trade unionism tends to become a menace to society at large; why should trade unionists at the National Industrial Council object to the scheme to teach wounded soldiers a trade, or rope round work for their unions and cause such a strike as at Horbury, Wakefield, against employment of non-union returned soldiers? Will labor continue to ignore such facts as these: (1) With a home-grown supply of food sufficient for three months in the year only, along with the increasingly adverse rate of exchange, we must make goods for export not poorer in quality and not greater in price than can be produced abroad; (2) since the passing of the Coal Mines Minimum Wage Act, 1912, there is a decreased annual output of coal per man, from 300 tons before the war to 183 tons now, whereas in the United States of America, in the same period, it has increased from 400 tons to 600 tons; (3) the cost of labor per ton of coal in 1913 was 6s. 10½d., now it is 21s. 10¾d.; (4) the pithead price in England, is now 29s. 4d., in the United States of America 11s. 2d., and steel rails, pig-iron, ship plates, are all produced more cheaply there. Restricted output means that everything is dear, employment will be scarce, and our industries will be beaten in the competition with the United States of America, Germany and Japan.

The Institutes of Mining Engineers protested by resolution against basing the Sankey Recommendations on unrestricted evidence from one section, while restricting the engineers' evidence to "wages and hours." Many of these recommendations have been operating since March—result, decreased output, increased prices, more frequent strikes and absenteeism. Nationalization or Government control increases costs to the poor, e. g.: (1) Government control of railways has lost not only the 50,000,000l. per year pre-war profits, but meant a further annual loss of from 40,000,000l. to 60,000,000l. (2) Partial government control of mines meant an annual loss of 50,000,000l., hence its transference to the public in the last 6s. per ton rise. Private enterprise gave coal to the people at 7s. to 10s. per ton, with sufficient profit and margin for good working conditions, improvement of machinery and greater comfort to the workers than in any other industry. Nationalization would not tend to foster men of inventive genius like Watt, Boulton and Murdock. Are we not facing dangers which beset the Roman Empire? A system of public doles then, as now, encouraged slacking, discouraged undertakings with distant and non-immediate returns, and led to ruin. There is a very large waste of the time, money and energy of business men taken up with the settling of labor troubles, troubles caused partly by government interferences between employer and employed.

The only remedy is "back to work," hard work, a far greater output, and abandonment of "ca' canny." To make output equal the demand will end profiteering. Confiscation of capital will not help. Profit-sharing, now that profits are so reduced, will not increase wages appreciably. The function of sound government is to maintain order and, stopping interference which chokes trade, to leave the differences between capital and labor to adjust themselves.

There is no peace in the house where the spoilt child is given everything it cries for. Just so, we have no peace because we give way every time to the wages and leisure the 4,000,000 trade unionists cry for. A grandmotherly government fears a greater row from a united 4,000,000 trade unionists than from the remaining 50,000,000, the greater half being the poorest, of the community. Instead of labor boasting that it has come into its own, would it not be truer to say that its demand for 37s. per ton in wages and transport had deprived the poorest of their coal and left their houses fireless, and enabled those who can work to outbid those who cannot work for the necessities of life.

Reinforced Brickwork in India

From The Railway Engineer, London.

The use of reinforced brickwork in India is referred to in the Technical Paper No. 191, on the use of Ferro-Concrete, recently issued by the Railway Board of the Government of India.

During 1913-1914 two single room tenements were constructed for the police in the Presidency District, Bombay, of reinforced concrete, but in these cases the cross partition walls are of brick on edge, set in cement mortar and reinforced at every alternate course with hoop iron. One of the chauls is five storys in height. In Assam, a district which is subject to frequent earth tremors, both reinforced concrete and reinforced brickwork have been found eminently suitable, and have been introduced where the necessary close supervision can be arranged for.

The residence for the Professor of Chemistry at Gauhati is a two-story building, the lower story being built of 10-in. reinforced hollow brick walls, aud the upper story of plastered ekra reeds fitted in timber frame work. The 10-in. walls were constructed with an outer shell 4½ in. thick and the inner shell 3 in. thick, with an air space of 2½ in. "Exmet" was used as reinforcement in every third ,and in alternate courses, respectively, in the two shells. The two shells were bonded together with a thorough bonding course at every 18 in. where the brick courses in both the shells come to a common level. Wet gunny bags were used until the mortar had properly set. The walls were surkee-plastered and whitewashed inside, the joints on the outside being struck to a weathered surface. The lintols over doors and windows are of reinforced concrete.

Only first-class bricks were used in the construction of the hollow walls, and the cement mortar was mixed in the proportion of 1 cement and 4 sand (sharp and clean). The cook shed of this building has a corrugated iron roof, and is also built of reinforced brickwork. The walls are about 8 ft. high and have been made only 3 in. thick, the bricks being laid on edge and reinforced with exmet in every alternate course. The proportion of mortar used was 1 cement to 3 of sand.

The residences for the Professor of Economics and the Professor of Physics at Gauhati were both built with main walls of 9½ in. reinforced hollow brickwork over ordinary pucca brick plinths, the partitions being 4½ in. reinforced brickwork built over terrace flooring. The hollow walls consist of two shells, each 3 in. thick, having an air space of 3½ in. between the shells, exmet being used as reinforcement in every third course. The bricks are laid on edge as stretchers in both the shells, and in order to connect the two shells 9½ in. headers, going right through the wall, were used in every course at intervals of three stretchers. To allow of thorough ventilation in the cavities between the shells fly proof wire gauze ventilator openings were introduced immediately above the plinth and below the wall plate level. Reinforced concrete lintols were used over doors and windows. The mortar was mixed in the proportion of 1 cement and 3 sand.

The Jail hospital at Sylhet is a two story building with reinforced brick hollow walls of exactly the same construction as the residences described above. The floor and roof are of reinforced concrete. The reinforcement of the brickwork was completely embedded in mortar and not exposed at any point. It was laid continuous so far as practicable, especially at corners where it was folded at right angles with an overlap of 2½ in. where necessary to join the ends. The work was copiously watered for about 3 or 4 days and kept wet for at least a fortnight. The joints on the outer faces of the external walls were struck to a weathered surface, and the inner faces treated with lime plaster and whitewash. The bricks were well saturated with water before use.

Certain bridges on the Powai-Digbai Road, Lakhimpur, were constructed with the abutments and wing walls of hollow reinforced brickwork filled in with ashes. The hollow walls consist of two shells 4½ in. thick each, with a 4½ in. space in the center. In some cases the foundations had to be carried deeper in order to prevent underscour. The soil being of a sandy nature the method adopted was to use reinforced brickwork as a shell which was sunk as a well foundation and subsequently filled in with concrete. Each well was roughly 15 ft. by 5 ft. with an angle steel curb secured to an angle and tee steel vertical frame filled in with 5 in. reinforced brickwork. Sinking was done partly by dredging and partly by ordinary excavation. The wells were taken down about 12 ft. and filled in with cement concrete. The reinforcement was of exmet placed at every fourth course, and the mortar was in the proportion of 1 cement to 4 sand.

Inferior class buildings are frequently built of 4½ in. reinforced brickwork, and 3 in. brick on edge reinforced walls may be also adopted for this class of building. But as 4½ in. reinforced walls may be unsupported for a length of 15 ft. against 10 ft. in 3 in. walls it will often happen that no economy is effected by the use of 3 in. walls. In all cases 2½ in. exmet reinforcement is used at every third course. The mortar consists of cement and sand, generally in the proportion of 1 to 4. When the quality of sand is poor the proportion of cement to sand in the cement mortar is generally 1 to 3. In low 4½ in. walls cement mortar is used in the reinforced courses only, the other courses being laid in lime mortar. Door and window lintols for the 4½ in. and 3 in. walls are of brick in cement reinforced in every course till the reinforcement in the general walling is reached. The outer faces of hollow or single 3 in. walls require no pointing. The joints are struck to a weathered surface as the work proceeds. In out-houses the inner faces of the walls are only cleaned and whitewashed and the lime mortar joints in the outer faces raked and cemented in keeping with the reinforced courses.

The reservoirs at Dera Ghazi Khan are cylindrical in shape, 27 ft. internal diameter, 14½ ft. deep, and are raised 16 ft. above the ground. The shell is built of burnt brick in cement 13½ in. thick for the lower half of the depth, the upper half being 9 in. thick. The shell is reinforced with rings of mild steel encircling it at every course and designed to take the tensile stresses produced by the pressure of the water. The rings are kept in position by radial rods built into the brickwork of the shell, one foot or so apart in every course, breaking joint and projecting out 5 in. or so. On these radial supports the encircling rings are laid, the supports being then turned up against the shell and bent round. The exterior of the shell is coated with cement plaster which thus encases the reinforcement. The interior of the shell is also cement plastered, "Pudlo" or "Medusa" being added to the cement. The reservoirs have been tested for water tightness with 11 ft. depth of water and found satisfactory.

Standardized Water Fittings in Brass Trade.—The standardization of water fittings, first proposed a year or two before the war, has been a bone of contention amongst the Birmingham brassfounders for a long time, according to The Engineer, of Dec. 5. It was recognized that the varying specification of waterworks engineers were sometimes faulty, often vexatious, and nearly always wasteful from a manufacturing standpoint. When at length the waterworks engineers laid down certain standards to which they could all subscribe their proposals were regarded by all but the theorists as so extravagant that hitherto people have refused to adopt them. It is considered that the fittings prescribed are unnecessarily heavy, and that a lower quality of metal would meet the case, the possible saving on these heads being put at 20 per cent. Manufacturers, too, are not at all convinced as to the desirability of rigid standardization as a nationally applied policy. Their view is that the diversity of the water fittings called for in this country has been a valuable safeguard to them against foreign competition. While the multiplicity of patterns in the brass trade generally has been drastically reduced, there are Birmingham manufacturers who fear that by rushing to the opposite extreme, more serious difficulties should be precipitated. Mass production along uniform lines may be organized on a much larger scale in certain departments with substantial economies, but it is felt that it can never entirely displace the older methods.

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